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SOME ASPECTS OF MODERN SURFACE COATINGS AND POST-WAR SYNTHETIC FINISHES

by C. J. A. Taylor, M.Sc., A.R.I.C.

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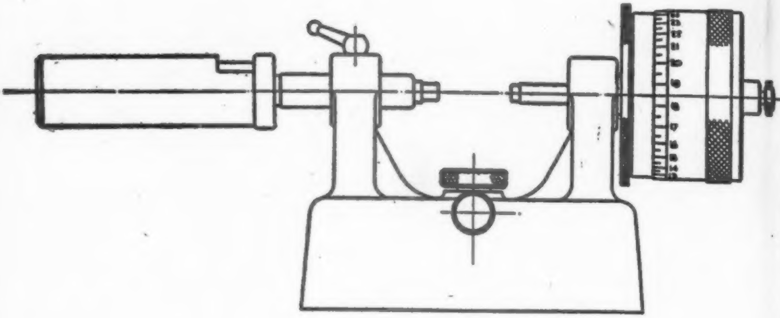

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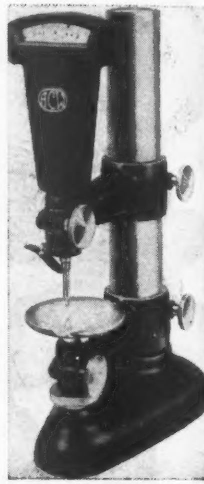

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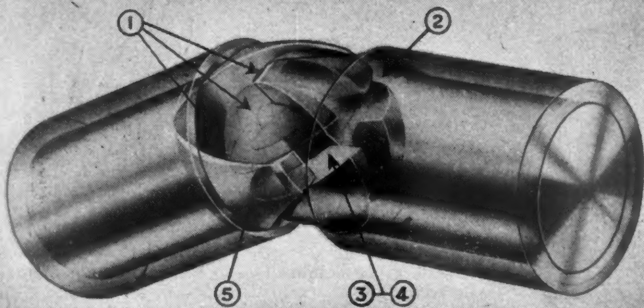

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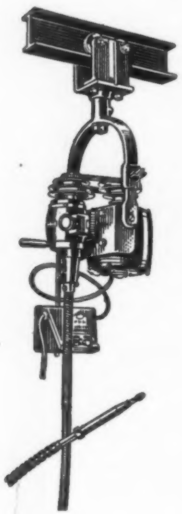

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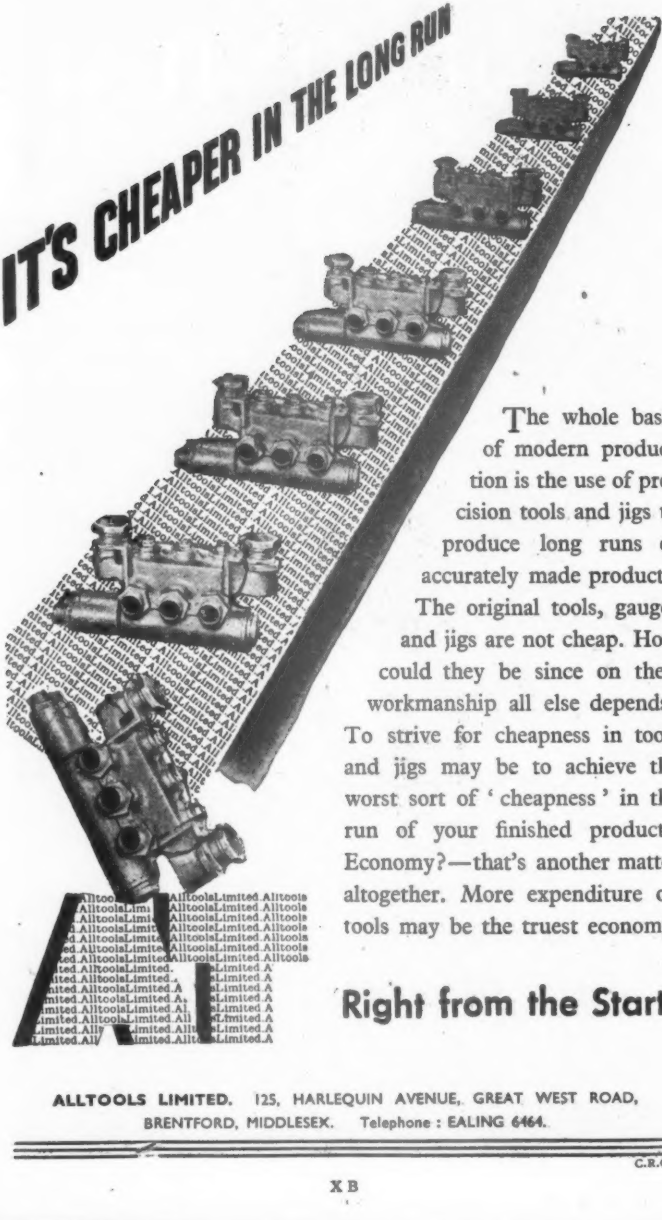

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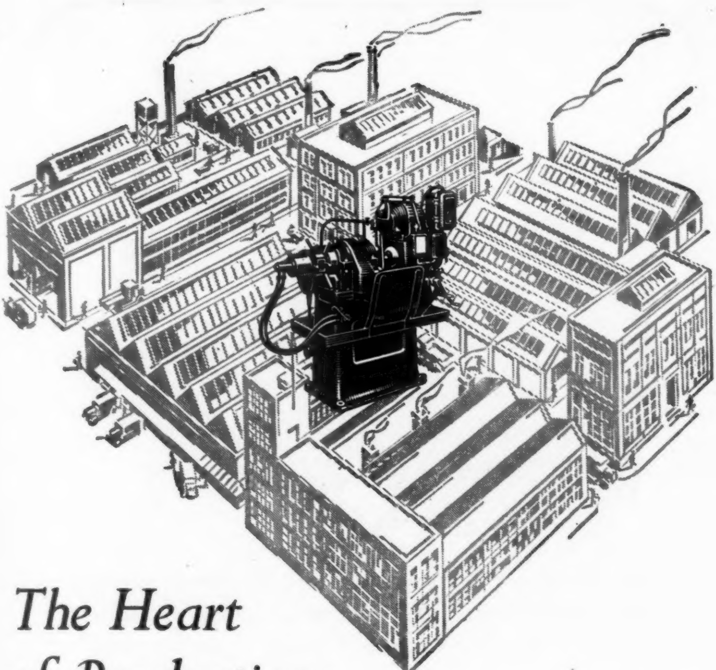

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SOME ASPECTS OF MODERN SURFACE COATINGS AND POST-WAR SYNTHETIC FINISHES

By C. J. A. TAYLOR, M.Sc., A.R.I.C.

Presented to the Wolverhampton Section, 24th January, 1945

Introduction.

PAINT or varnish applied to a surface may be intended to act solely as a protective coat preserving the material painted from destruction by ordinary weathering influences or by some particularly corrosive environment, or the coating may be intended to provide an otherwise drab looking object with a surface of pleasing appearance, or to enhance and preserve the beauty of some natural surface, for example, a nicely grained wood. In a great many cases the paint or varnish coating fulfils the dual rôle, both protective and decorative.

Coating from Drying Oils and Natural Resins.

In the early years of the present century, paints and varnishes were made almost exclusively from one drying oil—linseed oil.

Suitable pigmentation of this medium provided us with the simplest form of paint—ordinary oil paint—such as is covered in modern practice by British Standard Specification 929 for Ready Mixed Paints. These products are used extensively as protective paints for general structural work—metal or wood. They are usually applied by the brush and are characterised by ease of application and comparative slow drying—18–24 hours—to a soft but tough film of good adhesion and very good lasting properties. Their decorative value is low ; the film does not flow out to a smooth surface characteristic of an enamel, and gloss is poor.

Varnishes were made by combining linseed oil with fossil or copal resins. These are found in various tropical and sub-tropical regions. Here they were produced by certain trees a long period ago and have subsequently aged and hardened to their present state. Well known examples are Animi from Madagascar or E. Africa ; Kauri from New Zealand, and Congo Copal from the Belgian Congo, the latter being now by far the most widely used fossil resin.

Recent resins are obtained by tapping living trees ; such are Rosin obtained, together with turpentine from various species of pine ; Damar, Manilla, etc. Recent resins are much softer, more friable and more readily soluble in solvents than fossil resins and when made into varnishes are much less durable. In their natural state fossil resins are quite insoluble in linseed oil. For the manufacture of varnish, it is necessary to heat the fossil copal rapidly to a high temperature—300–350°C.—a process accompanied by considerable loss in weight. The resin now becomes soluble in oils. Hot linseed oil is slowly added and when resin and oil are thoroughly amalgamated, the mixture is allowed to cool somewhat, the requisite driers added, and finally the thinners—white spirit or turpentine.

Such a product, after a long period of tanking, for clarification and maturing, gave us the very fine old-time Copal Varnishes. With such products it was pretty safe to say that the durability was directly proportional to the drying time ; the longer their drying time, the greater the durability—(high proportion of oil and low proportion of driers). For a pure Copal Linseed Oil Varnish to possess good durability, a drying time of 18–24 hours must be expected. Such was the case with the old-fashioned Coach Body Varnishes and Exterior Decorators' Varnish. This long drying time brought in its train many troubles. During the drying period, the film was very susceptible to uncontrollable factors, such as sudden chilling, deposition of moisture, rain, and, of course, liability to pick up dust, troubles which, with the modern quick-drying synthetic varnish, have largely disappeared.

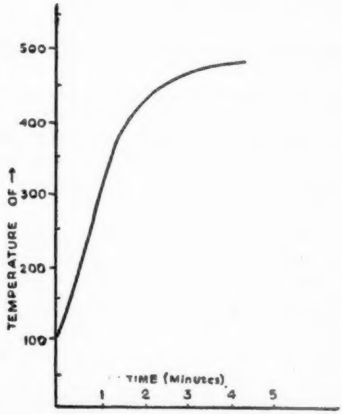
It must not be assumed, however, that Copal Linseed Oil Varnishes are entirely a back number ; such is far from being the case. In 1936, 26,000 tons of fossil Congo copal was imported into this country. As an air drying finish, copal varnishes find extensive use as interior Oak Varnishes and for Interior and Exterior Metal Primers, where their adhesion and anti-corrosive properties are of value ; for example, in CS.1482. With such products the conversion of the liquid paint films into a resistant coating takes place (after evaporation of the thinners) by a complicated oxidation process which converts the linseed oil into a tough elastic solid.

In stoving finishes, Copal Varnishes maintain an extensive field of use.

At this point we might consider the general advantages of stoving finishes. Compared to an air drying finish, the stoving finish will possess superior adhesion, toughness, resistance to hard-wear, weathering and attack by chemicals, oils, greases, etc., and for industrial work, the stoving finish will possess the enormous advantage of speed ; within two hours, for example, a surface can be coated with a durable protective finish. The use of the stoving finish has been restricted by the nature and size of the article to be painted.

Stoving times have been substantially reduced by the development of radiant heat drying, either by the specially developed electric bulb and its reflector, or by radiant heat gas ovens. On theoretical grounds, we would expect radiant heat to be a quicker way of heating a given surface, than by conduction or convection, and such proves to be the case in practice.

For a critical survey of radiant heat drying, reference should be made to the recent book by Messrs. Nelson and Silman of J. Lucas & Co., and to a recent paper by Mr. Atkin of the Industrial Research Laboratories, City of Birmingham Gas Dept. (*Gas Journal*, September 20th and 27th, 1944). The enormous advantage of the infra red process lies in the reduction of stoving time it makes possible—a few minutes instead of one or two hours—given a suitable article, preferably of sheet metal and of high surface to wt. ratio and a suitable paint.



For coating certain types of mass-produced war equipment, the process has been invaluable—the special four-gallon petrol tank or "jerry can" being a good example. In the radiant heat oven the radiation surface stands at a high temperature, varying from 600°F. to 1,000°F. The rate of temperature rise of a sheet metal panel introduced into such a stove is shown on the illustration. (By courtesy of Mr. F. L. Atkin).

The rate of increase is at first very rapid A–B slowing up as convection losses come into play and the temperature of the panel approaches that of the source of heat. In practice the lower part of the curve A–B is used, the work being taken from the tunnel at a predetermined time ; hence the need for precise timing as the margin between correct stoving and spoilage by over-stoving is not very great. (Atkin, *loc. cit.*). As far as the paint is concerned, coatings which dry by a thermo-hardening or polymerisation process as distinct from oxidation process, and at the same time have good heat resisting properties, will be most amenable to infra red stoving.

The expense and maintenance of the electric system makes it a doubtful proposition compared with the gas heated radiant oven, as will be seen from the figures as quoted by Mr. Atkin from production experience at Messrs. J. Lucas's works.

Comparison of gas-fired radiant heat tunnel and electric infra red tunnel.

	Gas.	*Electric.*
Output of articles per hour	600	600
Length of heating zone	9 ft.	32 ft.
Time to pass through heating zone ...	1·7 mins.	6·6 mins.
Cost of installation	£135	£1920
Energy consumption per hour	480 cu. ft. (2·16 therm)	96 Kw.h.
Running cost per hour for 600 articles ...	1/-	4/9d.

The electrical process has a certain degree of flexibility not possessed by the gas-heated stoves in that the position and number of electric lamp banks can be adjusted at will to suit runs of articles of varying size and shape. Where expense is no object, for example, it can be extended to deal with articles not normally considered suitable for stoving, *e.g.*, tanks.

Prior to the advent of radiant heat drying the normal method of stoving was carried out in box ovens (for batch work) or in conveyor ovens for continuous flow work. Such ovens normally operated at temperatures varying from 200°F. to 350°F. Although such ovens are usually classed as convection ovens, a substantial proportion of the heat intake of articles passing through is by radiation.

As pointed out by Mr. Atkin, convection ovens will continue to be indispensible for the following reasons :—

(1) The work may remain in the stove for considerable periods in excess of normal drying time without being spoiled.

(2) Articles of different sizes, shape and thickness may be stoved together without spoiling, although it will be obvious that the smaller articles and those placed nearer the sides and top and bottom of the stove are likely to be finished first. For an establishment handling a wide variety of articles, therefore, the convection oven will remain the most generally useful stoving equipment.

Returning now to our stoving congo-copal linseed oil varnishes we find such materials used for many protective coating purposes on account of its good adhesion, water resistance and resistance to several reagents. As examples one can quote—lead-free copal varnish for the inside and outside of H.E. shells—a remarkable tribute to copal varnish that it still holds this vital field. Also acid resisting varnishes for interior of food cans ; here the varnish is roller coated on to tin plate in sheet form, stoved and subsequently fabricated.

Pigmented copal varnishes are used for many varieties of stoving primers and enamels for industrial work. Copal media are appreciably lower in raw material cost than synthetic media.

Coating containing China Wood Oil.

China wood oil is obtained from the nuts of certain trees indigenous to the Yangtse Valley district of China.

The recognition of the value of it in surface coatings came during the period of the first German war—1914–1918—when it was found that varnishes based upon Rosin or its simple derivatives used with China wood oil, were superior to copal linseed oil varnishes in respect of water resistance and also to some extent in speed of drying and hardness. You may ask why the China wood oil is combined with a comparatively low grade resin such as Rosin instead of with the more durable fossil copals. The answer is that China wood oil thickens or polymerises very rapidly under the influence of heat—far more quickly than does linseed oil—and readily changes to an insoluble unworkable mass or gell. In the processing of fossil resins, it is essential, as we have seen already, to use very high temperatures, over 300°C., and China wood oil at this temperature would gall in less than five minutes—that is, before the two materials could be amalgamated. Rosin, however, melts at a much lower temperature and, moreover, exerts a restraining influence on the thickening or polymerising of the China wood oil with the result that the bodying can be easily controlled and successful varnishes made. The China wood oil itself dries to a much harder and tougher film than linseed oil and so off-sets the softness and poor durability that would normally be expected from a varnish containing Rosin as a resinous ingredient.

Phenolic Resins.

The subsequent improvement in China wood oil varnishes came from the development—about 1920–30—of a type of synthetic resin known as Rosin Modified Phenol-formaldehyde Resins. These products are related to the Bakelite resins, which by this time were well known to the moulding industry. The Bakelite resins are obtained by reacting together phenol or cresols with formaldehyde in approximately equal molecular proportions, when the embryo resin separates as a heavy syrup or solid material which is readily soluble in alcohol. Further heating converts this material into an insoluble and infusible resin of extreme hardness, resistant to oxidation, solvents, chemicals, alkalies, etc. The transformation by heat of the spirit soluble, or "A" form of the Bakelite resin into the insoluble and infusible " C " form, constitutes, of course, the basis of the Bakelite moulding industry. Resins or coating materials which undergo this type of change are said to be thermo-hardening. Attempts to utilise the spirit soluble thermo-hardening phenol-formaldehyde resins in stoved surface coatings, did not meet with immediate success. Although the stoved films were extremely hard

and resistant to water, chemicals and almost all solvents, they are extremely brittle and lack good adhesion, so that the slightest bending of the metal would cause fracture and flaking of the film. Further, the appearance of the stoved film was frequently poor, showing pinholes, bubbling and other surface defects.* It proved impossible to find a really satisfactory plasticiser for such resins and all attempts to combine them with linseed oil or other oils, to improve elasticity and adhesion, proved abortive.

The prize to be gained—chemical resistance and hardness—of a Bakelite type resin, combined with some measure of elasticity and adhesion—was so great that extensive research was carried out in this country and on the Continent to obtain compatibility between phenol-formaldehyde resins and drying oils. The problem was partially solved in Germany by Albert and others. The phenol-formaldehyde resin in its early "A" stage, is combined with Rosin and the product subsequently neutralised with glycerol, giving a resin which was soluble in linseed and other oils. Such resins were introduced under the name of "Albertols" and have proved valuable and versatile materials for the surface coating formulator. Combined with China wood oil or with mixtures of China wood oil and linseed oil, the Albertol type resins produced quick drying—4–12 hours—water resistant varnishes, used in a variety of industrial and decorative finishes, for example, insulating varnish, spar varnish, marine varnish, floor varnish, enamels for the industrial coach building and decorating trades. Such varnishes were quicker drying and more water resistant than the older copal varnishes, and, furthermore, the long periods of tanking or maturing necessary with the latter are avoided. Nevertheless, it must be realised that the success of the Albertol type resin was largely due to the readiness with which they could be compounded with China wood oil, thus enabling the valuable properties of this oil to be exploited and considerably stepping up the performance of Rosin/China wood oil varnishes.

Pure or 100 per cent. Oil Soluble Phenolic Resins.

The Albertol type resins contain at the most about 25 per cent. of phenol-formaldehyde resin, the remainder being the Rosin or its derivatives and it was obvious that the latter must detract from the durability and resistance which might be attained if a pure oil soluble phenolic resin could be made. This was first done in 1928 by the Bakelite Corporation, who introduced a pure 100 per cent. phenol-formaldehyde resin, Bakelite 254, which was soluble in China wood oil and linseed oil. Combined with China wood oil, this new oil soluble Bakelite resin gave us short oil varnishes of amazing speed and outstanding resistance to water, alkalies, and chemicals generally, probably the highest degree of resistance which can be

* Within recent years these defects have been eliminated by chemical modification of the thermo-hardening phenol-formaldehyde resins.

reached with any oleo-resinous composition. Bakelite 254 has one unfortunate property—that of marked yellowing on exposure to light. Later on, however, pure phenol-formaldehyde resins were developed which were much better in this respect. The difference between the thermo-hardening phenol or cresol formaldehyde resins used in the moulding industry, which you will remember were incompatible with drying oils and the pure oil soluble phenolic resins, lies in the chemical nature of the phenol used. To be capable of yielding oil soluble resins, the phenol must contain within the molecule, certain chemical groups, and we refer to them as higher substituted phenols. These raw materials have only been made hitherto in America, on whom we have to depend for supplies and they are very high in price. Consequently, the use of 100 per cent. phenolic resins has been cut to the minimum during the past five years. In varnish media, 100 per cent. phenolic resins give their best results when they are combined with China wood oil. Proportions of linseed oil may be added at later stages of the cooking process and the latter helps to maintain the elasticity in films intended for long exterior exposure. The resultant varnishes possess a rapidity of drying, hardness and resistance to water which is outstanding in oleo-resinous medium and they are very durable. Hence they are widely used in seaplane and boat varnishes and in many other types of high-class finishing and protective varnishes. Pigmented materials are used as anti-corrosive and primings on steel and light alloys for aircraft, etc., and paints for railways, buses, etc.

Varnish based on Bakelite type resins have been used to solve many difficult problems in surface coating ; for example, protection of steel in river and harbour waters ; painting of structural steel including forms for cement construction ; protecting the inside of steel water tanks and " sour " crude oil tanks.

In stoving products the pure phenolic resins find application in varnishes for electrical insulation ; varnishes for the canning industry ; low temperature stoving varnishes for protection of electrical equipment.

The rapidity of drying of the above types of finishes are not obtained without one defect, namely, rapid skinning in containers. Although this tendency can be restrained, it cannot, from the very nature of the material, be entirely overcome. Further, all phenolic resin coatings, both of the Rosin modified and 100 per cent. type have a marked tendency to yellowing on exposure—in some resins, more pronounced than others, but always more marked than with, say, alkyd finishes to be described next.

" Glyptal " or Alkyd Resins.

We now turn to an entirely different type of synthetic resin,

referred to as an "Alkyd" or "Glyptal" Resin. Glyptal is a trade name, the property of the General Electric Co., who first developed this type of resin.

In general, Alkyd resins are prepared by the condensation of a polybasic acid (an organic compound with two or more acid groups within its molecule, or its anhydride—*e.g.*, phthalic anhydride)—with a poly-hydric alcohol such as glycerol. Reacting these two ingredients, phthalic anhydride and glycerol, one obtains a water white resin, possessing thermo-hardening properties. In the "A" stage this resin is soluble in such solvents as acetone, and by further action of heat, it may be converted into the insoluble and infusible "C" form. The rate of transformation into the "C" form is slow, which makes the resin unsuitable for moulding purposes, and it has but limited application as a coating.

The valuable coating alkyd resins are obtained when the Alkyd is modified by the introduction of non-drying, semi-drying and drying oils, which, after reaction, become an integral part of the resin itself.

Non-drying Oil Modified Alkyds.

Alkyds modified with non-drying oil, such as castor oil, vary from medium hard resins to soft balsam-like materials. Possessing no air drying properties, they are used as adjuncts to other film-forming materials. In particular they are employed as resins or resin-plasticisers in nitro-cellulose lacquers, on films of which they confer high durability. A further important application is as plasticiser for thermo hardening urea or melamine resins used in white stoving enamels. The resistance of the alkyd to discolouration under light and heat, renders them invaluable in this connection.

Drying Oil Modified Alkyds.

The use of these media in the coating industry has grown with astonishing rapidity in the past 10 years. Drying oil modified alkyds have made possible the production of finishes which combine the desirable characteristics of speed of drying, colour and gloss retention, and remarkable durability to weathering.

For convenience of discussion of their application, the drying oil alkyds may be divided roughly into three groups according to the extent to which they are modified with oil.

1. *Short Oil Alkyds.*

Short Oil Alkyds—containing less than 40 per cent. oil—are usually insoluble in white spirit or American turpentine and are used in xylol or naphtha solutions, applied almost exclusively by spray application and stoved at temperatures varying from 200–350°F. The resultant films possess excellent adhesion to metal surfaces combined with a toughness and flexibility which cannot be approached by the typical oleo-resinous finishes of comparable drying speed ; in addition oil and petrol resistance is good and

exterior durability excellent. They are not resistant to alkalies. Further advantages in speed of drying, hardness and resistance can be obtained by blending such media with etherified urea or melamine resins and such products, which dry more by polymerisation than by oxidation, respond well to modern methods of radiant heat drying. Stoving alkyds are used as coatings in an extremely wide range of industrial products.

2. *Medium Oil Alkyds—Containing* 40–55 *per cent. Oil.*

Modified with drying oil these products are used in stoving finishes possessing greater flexibility than the above. They are employed in roller coating enamels being applied to sheet metal, which, after stoving, are fabricated into many types of articles.

With addition of driers the medium oil alkyds may be used in quick air-drying finishes of superior durability for application by spray and such products have been widely used in coating vehicles of all types. They are also used in the formulation of stoving primers and fillers.

Wrinkle finishes afford another important application of medium oil alkyd resins. Such finishes comprise a special type of stoving enamel for industrial uses, which has been developed from what in normal circumstances is a serious paint defect. The film on drying, first surface skins and then swells and wrinkles instead of remaining smooth and continuous. The industrial value of such finishes lies in their ability to cover up minor surface irregularities, in a metal surface and so produce a pleasing decorative effect in one coat. These finishes are usually sprayed in a fairly heavy coat—stoved, to develop the wrinkle—and subsequently hardened at about 120°C. Peace-time uses included such articles as radio cabinets, typewriter parts, scientific instruments, etc., while war-time uses include instrument panels where lack of reflective properties in a black wrinkle finish is of value. The medium oil alkyds are not sufficiently soluble in such solvents as white spirit or turpentine, and are too quick setting to permit of successful brush application.

When semi-drying oils are used as modifying agents both the medium and short oil alkyds have a special field in the preparation of white or pale tinted enamels applied by spray or roller coating and stoved at 200–250°F. Such products possess good colour retention in daylight or darkness and are used in coating refrigerators—a wide field in the U.S.—and for such articles as tooth-paste tubes, closures, boxes and similar articles which may be stored for several months in closed boxes, where retention of whiteness is essential.

3. *Long Oil Alkyds.*

Long oil alkyds modified with above 55 per cent. drying oil are soluble in aliphatic hydrocarbons. The longer oil types have

obtained extensive use in the decorating field, where they have established entirely new standards of gloss retention and durability.

Careful formulation and processing of the alkyd are essential to obtain good application and thorough drying properties. Prior to the war such finishes were being quite extensively used by decorators on public buildings, factories, hospitals and private houses. Finishes based on medium and long oil alkyds have also established themselves as finishes for railway coaches, buses, commercial vehicles and, of course, aircraft.

In U.S. vast quantities of oil modified alkyds are being used on military vehicles of all types, tanks, jeeps, etc., and on a wide variety of military equipment. They are coated with a rust inhibitive primer and olive drab lustreless enamel based upon a pure long oil alkyd. The property of an alkyd enamel to resist chalking and colour changes is of vital importance in these paints for military equipment ; to obtain the initial matt surface required in the paint film a high proportion of pigment and inert filler in relation to the binder is required ; any weakness in the binder will be quickly reflected by chalking and colour change of the coating on exposure.

The durability and non-chalking characteristics of alkyd finishes is also reflected in their adoption by the U.S. Navy for practically all areas of ships above the waterline—a long oil alkyd of relatively low viscosity is used—dark grey paint for the hull and superstructure and white enamel interior paints.

For light metal used in aircraft construction a zinc chromate primer on an alkyd resin base is frequently used ; such resins usually contain China wood oil as part of the modifying oils. The use of the versatile and valuable alkyd resin in this country during the war has been very much restricted owing to shortage of phthalic anhydride, a situation which should never have been allowed to occur. Alkyds have been restricted by Government control to use on aircraft and for a limited range of other products of A.1 priority. To-day the situation is even worse. You will have observed from the published casualties of the Burma campaign, the extremely high rate of sickness from malaria. Now one of the most effective anti-mosquito materials known is Dimethyphthalate, made from methyl alcohol and phthalic anhydride. Enormous quantities of this material are required for our troops in the Far East, who rub their bodies daily with the Dimethyphthalate in the form of a vanishing cream. The result is that alkyds have vanished from the materials available to the surface coating industry. No one will quarrel with the decision to take all the available phthalic anhydride for the anti-malaria preparations, so you must be patient with your paint supplier when he tells you that you cannot have what is probably the best coating material for your particular job until after the end of the Far East war.

Urea and Melamine Resins.

We now turn to two types of synthetic resins which are truly thermo-hardening products and which are consequently used in stoving varnishes.

Urea-formaldehyde Resins in Surface Coatings.

Urea-formaldehyde resins, as used in plastic mouldings, are water soluble condensation products ; for use in the coating industry, a change in solubility relations is necessary ; the products now in use are chemically combined with a suitable alcohol and become soluble in aromatic hydrocarbons such as naphtha or xylol and readily compatible with alkyd resins. Being essentially thermo-hardening products, their main applications are in stoving finishes.

The urea resins alone stoved in film form give a colourless, very hard but brittle coating, characterised by high resistance to discolouration under light or heat. They are mostly used plasticised with suitable alkyd resins. The urea-formaldehyde resins and alkyd resins are complementary in stoving products, each type imparting to the other a number of desirable properties. The urea resins improve colour and colour retention on baking and suppress " after-yellowing " and considerably increase the hardness with shorter baking times than is possible with the pure alkyd. Conversely, the alkyd imparts properties of gloss elasticity and adhesion. The hardness and heat resistance of these finishes, have rendered them suitable for articles previously finished in vitreous enamel.

Such stoving finishes were, prior to the war, in extensive use on refrigerators, hospital equipment, kitchen cabinets, etc., where hardness, colour retention, grease and moisture resistance are of importance ; also for metal furniture, washing machines, bathroom fittings, etc. They are to be used for interior metal fittings of the Portal and other types of prefabricated houses. Alkyd-urea finishes are also resistant to oil, petrol, alcohol, etc., and are therefore used for articles likely to come in contact with these agents, *e.g.*, automobile wings and bodies, jerry-cans, head lamps, etc., while their heat resistance permits of such applications as coating for gas and electric fire surrounds ; electric irons, etc. Alkyd-urea finishes should be stoved for half to one hour at 260–300°F. for maximum resistance and durability.

Melamine Resins.

The comparatively recent introduction of melamine-formaldehyde resins, has resulted in a further improvement in the properties of synthetic stoving finishes. For use in surface coatings etherified products are made by carrying out the condensation of melamine and formaldehyde in the presence of alcoholic solvents—usually butyl

alcohol. The products are hydrocarbon soluble and are readily converted by heat or by acid catalysts, into a water-white, extremely hard but brittle film. As in the case of urea resins, the oil modified alkyds are the best plasticisers. Such finishes possess, compared with the corresponding urea-alkyd combination :—

(1) better light fastness ;
(2) better gloss retention during stoving ;
(3) greater speed of hardening ;
(4) greater resistance to heat ;
(5) superior resistance to sea-water, dilute acids and alkalies ; and to oils, grease and to such solvents as petrol and alcohol.

Such finishes will, therefore, find an extensive use on refrigerators, hospital equipment, and especially for finishes exposed to heat, *e.g.*, surrounds of electric fires, gas fires and stoves, electric irons, etc., where they replace vitreous enamels.

Finishes which harden at room temperature may also be formulated with urea and melamine resins by introduction of a suitable acid catalyst ; such finishes may prove of interest to the wood finishing trade, because of their mar-proof qualities. The release of the information that the De Havilland Mosquito is assembled by the use of cold setting urea-formaldehyde adhesives, the skin being synthetic resin bonded plywood (mainly phenolic) draws attention to another important application of urea and melamine resins.

Thermo-plastic or Non-convertible Materials in Surface Coatings.

Thermo-plastic materials such as celluloid and cellulose acetate plastics, styrene, P.V.C., etc., are distinguished sharply from thermo-hardening materials by their behaviour on heating. A thermo-plastic material will soften so that it can be moulded and on cooling regains its original hardness—a process which can be repeated indefinitely. Thermo-hardening materials, on the other hand, are changed on heating by various chemical processes, with the result that they harden into a form which cannot again be softened by heat. In the coating industry, we use thermo-plastic materials by dissolving them in suitable solvents and applying the solution—pigmented or otherwise—to the surface by spray or other means. The coating then dries by evaporation of the solvent only. No further change takes place either by oxidation or other chemical change, with the result that the film remains permanently soluble in the solvents from which it was originally laid down.

In the majority of industrial finishing processes, recovery of this solvent is impracticable and as the latter may comprise as much as 70 to 80 per cent. of the weight of lacquer, this results in a serious economic loss. In this connection the technique of hot application of lacquer is of interest and also the use of lacquers in emulsion form.

Cellulose Derivatives.

Of the thermo-plastic materials, cellulose derivatives were the first to attain substantial use in the industry, being developed shortly after the end of the last German war, when plentiful supplies of nitro-cellulose and of a suitable solvent, *viz.*, butyl acetate, became available. At that time—1920–24—quick drying finishes based on wood oil and phenolic resins and on alkyd resins had not been developed and the cellulose lacquer found a ready market in the motor car industry, which was then developing on mass production lines. Since that time cellulose lacquers have, by constant study, been brought to a high state of perfection.

Among recent improvements are :—improvement in gloss and perfection of the lacquer surface direct from the spray gun (reducing time for cutting down and polishing) ; lessening of chalking on outside weathering ; increase in solid content of the lacquer at spraying consistency.

At the outbreak of the present conflict, nitro-cellulose finishes were extensively used in the following industries :—automobile, furniture and leather finishing ; artificial leather ; aeroplane dopes ; metal lacquers ; lacquers for finishing of innumerable industrial articles ; for moisture proofing wrapping materials such as paper and regenerated cellulose films ; and cheap varieties in pottery and toy trades.

The advantages of cellulose lacquers are most striking where mass production methods demand great speed of initial set and a minimum of time lag between application and handling of the finished article ; where hardness, tensile strength and beauty of finish are of importance and where articles damaged on production lines may be rapidly made good. (Davis, J., *Oil and Colour Chem. Asstn.*, 1944, 27, 45.)

Stoving finishes based on alkyd resins were replacing nitro-cellulose lacquers in certain fields prior to the war, *e.g.*, mass-produced cars, and they were well established in the field of small industrial finishing. Advantages of the stoving " synthetic " finish compared with lacquer are :—

(1) higher solid content at spraying viscosity, leading to better " build " in fewer coats ;
(2) increased gloss obviating need for polishing ;
(3) greater durability and resistance to " chalking " of the finish.

Recent improvements in alkyd finishes coupled with the advantages of radiant heat drying will probably result in further replacement of N.C. finishes in post-war years. From the point of view of the car user and refinisher, however, the lacquer finish has much to recommend it.

The use of industrial nitro-cellulose finishes has been greatly restricted during war years, the available supplies being mostly required for aeroplane finishes and other similar requirements. With

the end of the present German war, plentiful supplies of nitro-cellulose will be available and provided the necessary plasticisers and solvents are equally available, will provide the immediate post-war coating for the motor car, furniture and industrial finishing trades. The saving of solvent by hot spraying of cellulose nitrate lacquer has been briefly mentioned. The viscosity of nitro-cellulose lacquer is considerably reduced when heated to 80–90°C., so that the film thickness deposited is equivalent to two or more normal coats. The solvent balance of the lacquer needs adjustment to ensure a good flow, the more volatile components of a normal lacquer being eliminated. The process has not made much headway in this country, although it appears to have been employed in Germany and the aircraft finishing industry in the United States.

Another development in cellulose lacquer technique which may possibly obtain some use for mass-produced cars after the war is the so-called cellulose re-flow process. This consists essentially of a nitro-cellulose lacquer containing a high proportion of a special type of non-drying alkyd resin, which, when heated to about 220–240°F. for a short time, is sufficiently fluid to flow to a smooth mirror-like surface. The panels are coated with a stoving primer and surfacer, followed by a sealing coat. Finally, the cellulose coats are applied, rubbed to a smooth surface and then stoved at 220–240°F. for about 20 minutes.

From a mass production point of view, the advantage of this process lies in the elimination of the polishing process used with the conventional lacquer.

The use of nitro-cellulose lacquers in emulsion in an aqueous medium as a means of saving organic solvents has been studied for some years. Such emulsions have a definite value in the coating of porous surfaces, such as paper, fabrics, leather, etc., enabling the lacquer film to remain on the surface. They are used for treatment of leather used for aviation jackets and other wearing apparel, as well as many types of upholstery leather. The leather is water-proofed and attains better flexibility, wearability and greater resistance to scuffing.

Other Cellulose Derivatives.

Cellulose acetates, mixed esters, and cellulose ethers have been intensively studied to remove two defects common with nitro-cellulose finishes—inflammability and deterioration of the clear film in sunlight.

Cellulose acetate lacquers maintain their use in certain special spheres, such as cable lacquers.

The mixed esters—cellulose acetopropronate and aceto-butyrate have been developed in the United States, where they are used in aircraft dopes, exterior clear lacquers, etc.

Ethyl Cellulose. The use of this plastic in surface coatings has been slowly but steadily increasing in recent years and it is now being manufactured in this country.

Notable advantages of ethyl cellulose over the esters are :—heat stability, flexibility, retention of flexibility at low temperatures, toughness, light resistance and resistance to alkalies. Ethyl cellulose lacquers are, therefore, particularly adaptable as flexible coatings for paper, leather and cloth ; as an electrical insulator in such fields as special insulating varnishes, cable-covering lacquers, extruded wire insulators and as an impregnant. Retention of flexibility at low temperatures is of importance for cable coverings for aircraft. A recent application of ethyl cellulose is a protective coating for metal articles and spares, *e.g.*, rifles, camshafts, etc., sent to the Far East war zone, where perpetual heat and damp " make a packing case a stewpot and a store tent a Turkish Bath." A special ethyl cellulose composition is applied in a thick film ($\frac{3}{16}$ in.). It acts as a complete corrosion preventative, sealing off the article completely from water vapour and water. Further it is designed to exude an oil film over the article, which need not be wiped off before use. The ethyl cellulose coating is itself easily removed when required, by stripping with a sharp instrument.

Vinyl and Related Resins.

This important group of thermo-plastic resins can be regarded as derivatives of the simple hydro-carbon, ethylene $H_2C = CH_2$, which can itself be polymerised under suitable conditions to a tough flexible solid, used in the moulding industry on account of its superb electrical properties.

Polymerisation of ethylene and its derivatives of the general formula :—

$$\begin{array}{c} H_2C = \underset{\displaystyle X}{\underset{|}{CH}} \end{array}$$

X representing the substituting group (in the case of ethylene X = Hydrogen), results in the formation of long chain linear molecule usually according to the scheme :—

$$—CH_2—\underset{\displaystyle X}{\underset{|}{CH}}—CH_2—\underset{\displaystyle X}{\underset{|}{CH}}—CH_2—\underset{\displaystyle X}{\underset{|}{CH}}—$$

The properties of the polymers depend on the nature of the substituent and to a less extent on molecular weight. As a result of the C—C linkages in the polymer chain all the resins show relatively good resistance to attack by water, acids and alkalies. The hydrocarbon members of the series polyethylene and polystyrene are

characterised by outstanding electrical properties. The table shows the relationships between members of the group of resins.

Type	Monomer	Polymerising Unit	Uses
Polyethylene	Ethylene	$-CH_2-CH(H)-$	High frequency moulding.
Polystyrene	Styrene	$-CH_2-CH(C_6H_5)-$	Insulating mouldings. Luminous paint media.
Polyvinyl Chloride	Vinyl Chloride	$-CH_2-CH(Cl)-$	Extruded cable coverings.
Polyvinyl Acetate	Vinyl Acetate	$-CH_2-CH(O-CO-CH_3)-$	Adhesives.
Vinyl Chloride —Vinyl Acetate co-polymers	Vinyl Chloride and Vinyl Acetate		Canning lacquers. Corrosion resistant lacquers. Fabric coating.
Polyacrylates	Acrylic Ester	$-CH_2-CH(COOR)-$	Leather coating.
Polymethacrylates	Methacrylic Ester	$-CH_2-C(COOR)\cdot CH_2-$	Light and heat fast lacquers.

In the surface coating industry they have attained limited but important and specialised uses. Many resins of this group are expensive and further give solutions of high viscosity with comparatively low solid content at application consistency, frequently accompanied by poor spraying or brushing properties and solvent retention difficulties. This is unfortunate as many of the resins have some outstanding properties for a surface coating, *e.g.*, water-white colour, outstanding colour retention, etc.

Polyvinyl-chloride Resins.

These polymers are characterised by high resistance to water, acids, alkalies, oils, petrol and other chemicals and insoluble in most organic solvents. Their very limited solubility in available solvents precludes their use in the usual type of surface coatings, but extruded plasticised polyvinyl-chloride compositions have attained consider-

able use as insulating material for cables, etc. The use of such a material in the electrical industry is illustrated on the exhibit kindly loaned by Mr. Wintle of Messrs. Crabtree, Ltd.

Polyvinyl-chloride-acetate Polymers.

Resins obtained by the co-polymerisation of a mixture of vinyl chloride and acetate, have found some important uses in the coating industry. The properties and application of such resins vary with the vinyl chloride/vinyl acetate ratio and with the degree of polymerisation or average molecular weight. "Vinylite" V.Y.H.H. is typical of these products and contains 85–88 per cent. of vinyl-chloride. The 12–15 per cent. acetate present imparts solubility in a limited range of solvents, among which ketones, *e.g.*, methylethyl-ketone and methylisobutyl-ketone have been largely used.

The vinyl-chloride/acetate resins show marked solvent retention, consequently coatings must be stoved or force dried, which also serves to improve adhesion. Their applications depend upon their exceptional resistance to water, acids and alkalies, as well as to alcohols, grease, oils and fats. Being non-toxic, odourless and immune to bacterial and enzymatic attack, they can be used on food containers.

One defect of these resins is the darkening and decomposition through loss of hydrochloric acid on exposure to heat or sunlight, particularly if they are in direct contact with such metals as iron, zinc or tin ; hence the necessity for introducing small amounts of stabilisers, *e.g.*, lead compounds in such cases. When applied to metal surfaces it is necessary to bake the first coat at 350–370°F. for a short time to develop adhesion ; subsequent coats require a short bake at 275–300°F. to eliminate solvents. The coatings are tough and flexible and may be heat sealed. Vinylchloride-acetate resins have been very successful as protective coatings in the container field. The first large-scale application was for lining of beer barrels and later beer cans. In addition to beer, wine and fruit juices are also packed in cans coated with co-polymer vinyl resins. Other uses are: coating of containers required for alkaline materials ; of caps and closures for food, cosmetic and medical products ; "stop-off" lacquers for electro-plating ; corrosion resistance linings for processing equipment.

The use of coated foil and coated paper for packaging miscellaneous products from dehydrated food, cheese, etc., to soap, affords a further wide field for co-polymer resins. Highly plasticised co-polymers containing 95 per cent. Vinyl Chloride and 5 per cent. Vinyl Acetate, are being extensively used for cable insulants and for coating fabrics, either by caldering or knife coating, *e.g.*, raincoats, ground sheets, portable hangars used by the U.S. Air Force in the

Pacific, etc., for service use. Such materials do not oxidise or become sticky on ageing or storage, have high abrasion resistance, high fatigue life, are resistant to oil and grease, dilute acids and alkalies, and do not crack at low temperatures. Post-war applications will be found in the artificial and patent leather industries.

Acrylate and Methacrylate Resin in Surface Coatings.

Although the use of polymerised acrylic esters in surface coatings was suggested some 20 years ago, progress in their application has been hindered by lack of a suitable range of polymers and by price considerations.

In the plastic field, their use has been extensively developed during the war and there is no doubt that certain members of the group will find substantial uses as specialised coatings in the period following the war.

The acrylate and methacrylate resins differ considerably in physical properties. Polymethylacrylate is soft and somewhat rubber like; polymethylmethacrylate is a hard resin—often referred to as "organic glass." There is a gradual decrease in hardness and thermal yield point with increasing molecular weight of the esterifying alcohol. Butylmethyacrylate is soft and flexible at room temperature. The methylmethacrylate polymers have an exceptional range of properties for surface coatings. They are water-white, of unsurpassed clarity; stable to light; very stable to heat; excellent ageing properties; good adhesion; resistant to water; acids, alkalies and salt solution; of very good general durability. Spraying difficulties necessitate careful control of polymerisation and of solvent blends. Solvent retention is serious with air-dried films, a light stoving or forced drying being necessary to overcome this difficulty.

The higher esters of methacrylic acid intended for coating work are usually polymerised in solution form. Among possible uses of these flexible polymers are:—coatings for rubber, rubber cloths, leather goods, etc. The adhesion to these materials is good and adhesion and flexibility are maintained during prolonged ageing. The harder lower esters provide a promising medium for a number of industrial applications, where coat considerations are justified by their outstanding qualities.

In conclusion I would refer to two novel developments in industrial finishing which are being used in the United States, where they have been developed by the H. J. Ransburg Co. The first deals with spray coating of small articles and is designed to avoid loss of material by overspray. Four electrode wires charged to 85,000 volts are arranged at a distance of 11 inches from the article which is earthed. The current used is only 5 milliamps or less. As the spray droplets enter the ionised zone, they pick up a negative charge; each droplet then tends to repel its neighbour and at the same time to be attracted

towards the object being sprayed. This results in a more even distribution of the sprayed coating, even over parts of the object remote from the gun. By rotating the article at the same time, 83 per cent. of the material leaving the spray gun can be utilised.

The second development deals with the dipping process of applying coatings. The notable disadvantage of this process is the problem of how to deal with the accumulation of excess material at the " drain-off " point. A very slow rate of withdrawal of the article from the dipping vat is, of course, a great help. Cutting the viscosity with thinners can be carried to the point where the paint at the top ofthe article is too thin to provide adequate coverage or protection. The presence of thick accumulation or tears is of particular disadvantage with articles to be radiant heat dried, as the thicker portion cannot be adequately stoved without the remaining normal coat being over-stoved.

Electrostatic " de-tearing " is claimed to automatically remove this excess material and presents to the baking oven a uniformly coated piece. The method is being applied with economy in time and labour in the U.S.A. to wire coating, cartridge cases and numerous other articles, which were formerly sprayed.

The article to be coated is supported on a conveyor, dipped or flow-coated in any suitable manner, drained for 1–4 minutes. At this point the earthed article is carried over an insulated conducting grid energized by 85,000 volts at a current of from $^{1}/_{5}$ to 5 milliamps. This sets up an electro-static field which is particularly strong at prominences and points where drain off is apt to occur. Due to this attraction, the excess paint is removed and a smooth coating results ready for baking.

The limitations of the dipping and detearing are claimed to be very few. One is that the material must not be so thermo-plastic that it will re-flow in the bake oven sufficient to cause excess material to reform at the drain off points. Another requisite is that the excess material must accumulate at sections of small radii. The detearing from section of radius of more than a quarter of an inch is impractical and the process will not remove sags and runs from sides of flat surfaces.

My thanks are due to the following firms and gentlemen, who have assisted me in the provision of samples, photographs for slides, etc. :—

Messrs. Beck, Koller & Co., Ltd., England.

Messrs. Bakelite Ltd.

Messrs. Imperial Chemical Industries Ltd.

Mr. T. Wintle of Messrs. Crabtree, Walsall.

Dr. Nelson and Mr. Silman of Messrs. Joseph Lucas Ltd.

Mr. Atkin of The City of Birmingham Gas Dept., Laboratories.

Mr. Noel Heaton.

Messrs. Charles Stormont Ltd., and Messrs. Frederick Cooper Ltd., Industrial Finishers, Birmingham.

Messrs. Joseph Lucas Ltd.

and to my colleagues at Messrs. Thornley & Knight Ltd.—Mr. J. Bull and Mr. F. Beasley—and to the Directors of Messrs. Thornley & Knight Ltd., for time and facilities.

INSTITUTION NOTES

September, 1945

Extraordinary General Meeting—Official Notice.

NOTICE IS HEREBY GIVEN that an Extraordinary General Meeting of the Institution will be held at the Institution of Civil Engineers, Great George Street, London, S.W.1, on Friday, 28th September, 1945, at 11.00 a.m. for the purpose of considering and if thought fit passing the following Resolution with or without modification. i.e. :

> "That the revised Articles of Association circulated herewith be, and the same are hereby adopted as the Articles of Association of the Company."

By order of the Council,

C. B. THORNE,
Director-General Secretary.

September Meetings.

1st Halifax Graduate Section. Special meeting at the Technical College, Halifax, at 2-45 p.m.

5th Manchester Graduate Section. A lecture will be given by R. W. Eade, B.Sc., on "Radiology as Applied to Production," at the College of Technology, Manchester, at 7-15 p.m.

8th Shrewsbury Sub-Section. A lecture will be given by B. Thomas, Esq., on "The Theory of Ferrous Heat Treatment," at the Technical College, Shrewsbury, at 3-00 p.m.

10th Coventry Graduate Section. A lecture will be given by E. G. West, Ph.D., B.Sc., on "Some Post-war Uses of Wrought Aluminium Alloys," at the Technical College, Coventry, Room A5, at 6-45 p.m.

11th North Eastern Graduate Section. A lecture will be given by G. Batty, Grad. I.P.E., A.M.I.Mech.E., on "Forming and Generating," at the Newcastle and Gateshead Gas Company's Demonstration Theatre, St. John Street, Newcastle-on-Tyne, at 6-30 p.m.

12th Manchester Section. A lecture will be given by Austin Hopkinson, Esq., on "Full Employment in Industry," at the College of Technology, Manchester, at 7-15 p.m.

September Meetings.—*cont.*

12th Wolverhampton Section. A lecture will be given by R. A. Betteridge, Esq., on " Plastics," at the Dudley and Staffordshire Technical College, Dudley, at 6-30 p.m.

15th Halifax Graduate Section. Lecture and Works Visit to Hopkinson's Ltd., Huddersfield.

17th Derby Sub-Section. A lecture will be given by K. G. Fenelon, M.A., Ph.D., on " Environment and Output," at the School of Art, Green Lane, Derby, at 6-30 p.m.

19th Birmingham Section. A lecture will be given by W. A. Hawkins, Esq., on " Precision Thread Rolling," at the James Watt Memorial Institute, Great Charles Street, Birmingham, at 7-00 p.m.

21st Manchester Section. A lecture will be given by W. Puckey, M.I.P.E., on " Managerial Aspect of Full Employment in Industry," at the Mechanic's Institute, Crewe, at 7-15 p.m.

22nd Manchester Section. A lecture will be given by W. Puckey, M.I.P.E., on "Managerial Aspect of Full Employment in Industry," at Liverpool University, Liverpool, at 2-30 p.m.

22nd Nottingham Section. A lecture will be given by G. E. Windeler, M.C.E., M.I.Mech.E., M.I.Mar.E., on " Industrial Accidents," at the Demonstration Theatre, The City Gas Showrooms, Lower Parliament Street, Nottingham, at 2-30 p.m.

27th London Graduate Section. A lecture will be given by C. H. V. Morris, Esq., on " Manufacture and Application of Tungsten Carbide," at the Institution of Mechanical Engineers, Storey's Gate, S.W.1, at 6-45 p.m.

28th Coventry Section. Air Commodore F. Whittle, C.B.E., Hon.M.I.Mech.E., will give an address entitled " The Aircraft Gas Turbine," at the opening meeting at the Central Hall, Coventry, at 7-00 p.m.

28th North-Eastern Section. A lecture will be given by Dr. D. F. Galloway, B.Sc., Director of Research, I.P.E., on " Production Engineering Research," at Neville Hall Mining Institution Newcastle-on-Tyne, at 6-15 p.m.

October Meetings.

1st Coventry Graduate Section. A lecture will be given by R. L. Lloyd, Grad. I.P.E., on " Modern Practice in Multi-Spindle Automatic Design," at the Technical College, Coventry, Room A5, at 6-45 p.m.

October Meetings.—*cont.*

1st Yorkshire Section. A lecture will be given by F. Loxham, M.I.P.E., M.I.Mech.E., F.R.S.A., on "The Inspection and Preparation of Straight Edges and Flat Surfaces," at the Hotel Metropole, Leeds, at 7-00 p.m.

8th Manchester Graduate Section. A lecture will be given by Dr. D. Bennie on "Steel Making and Rolling," at the College of Technology, Manchester, at 7-15 p.m.

9th North-Eastern Graduate Section. A lecture will be given by R. B. Williams, Grad.I.P.E., on "The Construction of Machine Tools," at the Neville Hall Mining Institution, Newcastle-on-Tyne, at 6-30 p.m.

11th South Wales and Monmouthshire Section. A lecture will be given by A. H. Huckle, F.I.F.M., M.I.Ec.E., A.M.I.I.A., on "Production Planning and Control," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

11th Leicester Section. A lecture will be given by Dr. W. Wilson on "Electronics in the Service of the Engineer," at the Leicester College of Technology, at 7-00 p.m.

15th Derby Sub-Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Time Factor in Industry," at the School of Art, Green Lane, Derby, at 6-30 p.m.

15th Halifax Section. A lecture will be given by F. Loxham, M.I.P.E., M.I.Mech.E., F.R.S.A., on "Measurement of Straight Edges, Flat Surfaces, etc.", at the Technical College, Halifax, at 7-00 p.m.

17th Manchester Section. A lecture will be given by A. G. Doughty, Esq., on "Use of Disabled Personnel in Industry," at the College of Technology, Manchester, at 7-15 p.m.

17th Sheffield Section. Inaugural Address by F. C. Pickworth, Esq. Full details to be announced later.

18th Glasgow Section. A lecture will be given by A. Chalmers, B.Sc., H.M. Inspector of Factories, on "Accident Prevention," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, at 7-15 p.m.

19th Coventry Section. A lecture will be given by F. E. Rowland, M.I.E.E., on "Infra-Red Heating for Industrial Purposes," at the Coventry Technical College, Room A5, at 6-45 p.m.

19th Western Section. A lecture will be given by F. L. Daniels, M.I.P.E., M.I.Mech.E., F.G.S., on "Geology in Engineering," at the Grand Hotel, Broad Street, Bristol, 1, at 6-45 p.m.

October Meetings.—*cont.*

20th Manchester Graduate Section. Visit to L.N.E.R., Gorton. Particulars to be announced later.

20th Shrewsbury Sub-Section. A lecture will be given by N. Matthews, Esq., on "Principles of Foundry Practice," at Shrewsbury Technical College, at 3-00 p.m.

20th Nottingham Section. A lecture will be given by S. C. Roberts, F.C.W.A., W.I.I.A., on "Costing as applied to Production," at the Demonstration Theatre, The City Gas Showrooms, Lower Parliament Street, Nottingham, at 2-30 p.m.

26th North-Eastern Section. A lecture will be given by T. Swallow, M.I.P.E., on "Production Management Control," at Neville Hall Mining Institution, Newcastle-on-Tyne, 1, at 6-15 p.m.

November Meetings.

5th Coventry Graduate Section. "Any Questions"—Evening at the Technical College, Coventry, Room A5, at 6-45 p.m.

5th Yorkshire Section. A lecture will be given by T. G. Rose, M.I.P.E., M.I.Mech.E., F.I.I.A., on "How Money Moves in Business," at the Lecture Hall, City Museum, Leeds, at 7-00 p.m.

8th Leicester Section. A lecture will be given by E. Hunter, Esq., on "Cast Iron and the Machinist," at the Leicester College of Technology, at 7-00 p.m.

8th South Wales and Monmouthshire Section. A lecture will be given by Dr. W. Wilson on "Electronics in the Service of the Engineer," at the South Wales Institute of Engineers, Park Place, Cardiff, at 6-30 p.m.

13th Manchester Graduate Section. A lecture on "Press Tools" will be given by Messrs. W. A. Bull, Stringleman and Douglass; (Mr. Bull dealing with the scope of the subject, Mr. Stringleman with design, Mr. Douglass with manufacture), at the College of Technology, Manchester, at 7-15 p.m.

13th North-Eastern Graduate Section. Film evening at the Newcastle and Gateshead Gas Company's Demonstration Theatre, St. John Street, Newcastle-on-Tyne, 1, at 6-30 p.m.

15th Glasgow Section. A lecture will be given by A. L. Hipwell, Esq., on "Negative Rake Turning and Milling," at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2., at 7.15 p.m.

November Meetings.—*cont.*

16th Manchester Section. A lecture will be given by A. G. Doughty, Esq., on "Use of Disabled Personnel in Industry," at the Mechanic's Institute, Crewe, at 7-15 p.m.

16th Western Section. A lecture will be given by R. E. Rowland, M.I.E.E., on "Infra-Red Lamp Heat for Paint Drying," at the Grand Hotel, Broad Street, Bristol, 1, at 6-45 p.m.

16th Coventry Section. A lecture will be given by E. C. Dickinson, M.Met., at the Coventry Technical College, Room A5, at 6-45 p.m.

17th Nottingham Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Time Factor in Industry," at the Demonstration Theatre, The City Gas Showrooms, Lower Parliament Street, Nottingham, at 2-30 p.m.

18th Wolverhampton Section. A lecture will be given by H. E. Hows, M.Inst.B.E., at the County Technical College, Wednesbury, at 6-30 p.m., on "High Speed Forging Presses."

19th Coventry Graduate Section. A lecture will be given by J. H. Hobbs, Esq., on "Fine Measurement," at the Gas Showrooms, Rugby, at 7-00 p.m.

19th Derby Sub-Section. A lecture will be given by L. S. Delapena, Esq., on "Machine Tools," at the School of Art, Green Lane, Derby, at 6-30 p.m.

19th Halifax Section. A lecture will be given by C. A. Gladman, Esq., on "Engineering Drawings in Relation to Production and Inspection," at the Technical College, Huddersfield, at 7-00 p.m.

21st Manchester Section. A lecture will be given by Dr. D. F. Galloway, B.Sc., Director of Research, I.P.E., on "Machine Tool Research and Development," at the College of Technology, Manchester, at 7-15 p.m.

21st Sheffield Section. A lecture will be given by Dr. H. A. Fells on "Gas Furnaces and Industrial Heating," at the Royal Victoria Hotel, Sheffield, at 6-30 p.m.

24th Manchester Section. A lecture will be given by A. G. Doughty, Esq., on "Use of Disabled Personnel in Industry," at Liverpool University, at 2-30 p.m.

24th Shrewsbury Sub-Section. A lecture will be given by E. W. Hancock, M.B.E., M.I.P.E., on "Jig and Fixture Design," at Walker Technical College, Oakengates, at 3-00 p.m.

November Meetings.—*cont.*

27th North-Eastern Section. A lecture will be given by W. Shield, Esq., on "The Cost Accountant's Point of View in Relation to the Production Engineer," at Neville Hall Mining Institution, Newcastle-on-Tyne, 1, at 6-15 p.m.

September Committee Meetings.

25th The Education Committee, at 10-30 a.m., at the Imperial Hotel, Birmingham.

25th The Membership Committee, at 12-30 p.m., at the Imperial Hotel, Birmingham.

The Technical and Publications Committee meet every Wednesday at Institution Headquarters at 5-30 p.m.

Council Meeting.

The next meeting of the Council will be held on Friday, 28th September, 1945, at the Institution of Civil Engineers, Gt. George Street, S.W.1, at 11-00 a.m.

CORNISH SECTION. All members of the I.P.E., particularly those associated with the Cornish Section, will learn with the greatest regret that Mr. John Arthur has been compelled, owing to ill-health, to resign the Hon. Secretaryship to that Section. Mr. Arthur has undertaken these duties since the inauguration of the Section in 1938, and its members are indebted to him for his efforts on their behalf throughout these years.

SHREWSBURY SUB-SECTION. Mr. R. C. Fenton, of Messrs. Alfred Herbert Ltd., gave a most interesting lecture on "Negative Rake Cutting," at the Meeting, which was held at 3-00 p.m. at the Shrewsbury Technical College on 7th July. The lecture was attended by 46 members and visitors, and was followed by a lively discussion. Letters of thanks have been sent to Mr. Fenton and to Mr. A. Moore, Principal of Shrewsbury Technical College.

Personal.

Mr. T. Fraser, M.I.P.E., a director of Metropolitan-Vickers Electrical Co., Ltd., Vice-President and Past Chairman of this Institution, has been appointed to the Board of Hunting Aviation Ltd.

Mr. C. J. Hyde-Trutch, M.I.P.E., Chairman of the Nottingham Section and also of the Lincoln Sub-Section of the Institution, who for nine years has been Works Director of Ruston-Bucyrus Ltd., has been appointed a Director of Richard Crittall & Co., Ltd., London. Mr. Hyde-Trutch left Lincoln at the end of August.

IMPORTANT !

In order that the Journal can be despatched on time copy must reach the Head Office of the Institution by not later than 40 days prior to the date of issue, which will be the first of each month.

Books Received.

Sluice Valves for Waterworks Purposes, published by the British Standards Institution, London, S.W.1. Price 2/- net post free.

Retrospects, by E. Parkinson.

BOOK REVIEW.

Report of Joint Standing Committee on the Safety of Heavy Power Presses, entitled "Bending Brakes." (Official Publication.)

This is a report issued from His Majesty's Stationery Office dealing with the work of the Committee appointed to consider the fencing of Bending Brakes.

To quote from the introduction: "The specification appended to the Report sets out the performance required of a guard that will, in the opinion of the Committee, afford the necessary protection as regards the trapping area when used in conjunction with another or a similar guard to prevent access to that area from the back of the machine; and the report describes in detail the only guard yet on the market that meets this specification."

It is interesting to note that this report is published for the consideration of the Industries concerned and should therefore be of great interest to regular users of this type of machine, as the question of guarding brings in its train many problems if the guard is not seriously to impede the uses and efficiency of this type of press.

Research Department: Production Engineering Abstracts

(Prepared by the Research Department.)

NOTE.—*The Addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough. Readers applying for information regarding any abstract should give full particulars printed at the head of that abstract including the name and date of the periodical.*

ADMINISTRATION.

The Application of Statistical Methods to the Control of Industrial Costs, by Norman R. Neal. (*The Institution of Mechanical Engineers Journal and Proceedings, June,* 1945, *Vol.* 152, *No.* 1, *p.* 76, 5 *figs.*)

Quality control studies the variation from standard of tangible articles, whereas "cost control" studies the variation from standard of the workers' efficiency, and consequent variation in production cost. In essence, the system consists in setting standard times, and thus standard costs, for all jobs and for the elements making up the complete jobs. Percentage divergencies from those standards are recorded at regular intervals on charts, a separate chart being used for each class of work, both as regards time and cost. Control lines, calculated from previous results over a period upon the same mathematical principles as for quality control, are inserted on the charts. When a reading falls outside the control line, action must be taken to ascertain the cause. However, unlike quality control in which articles covered by abnormal readings can be scrapped, abnormal time or cost must still figure in the final examination production cost. A sufficiently fine subdivision of the elements of a job will prevent an occasional abnormal reading on one portion from giving abnormal reading for the complete job. The individual readings are combined to form a grand total chart; careful watching of the detail charts enables the grant total chart to be maintained in control and it is from the latter chart that the "cost index" (percentage divergence from standard of the cost of the complete product) is obtained, which enables the latest actual cost at a particular moment to be determined directly. A continuous check is thus kept on the production cost of all the principal details; any abnormal fluctuations of cost become quickly apparent, and can be readily traced back to their cause. Concurrently, a simple method is provided for obtaining the total actual cost of the complete product at any time.

Costing in the Small Works. (*Mechanical World*, *6th July*, 1945, *Vol.* 118, *No.* 3053, *p.* 9, 2 *figs.*)

Part II. Details are given of a simple scheme which makes for departmental team work.

COOLANT, LUBRICANT.

Refrigeration of Coolants for Machine Tools, by B. S. Williams. (*Machinery*, 19*th July*, 1945, *Vol.* 67, *No.* 1710, *p.* 72, 1 *fig.*)

High temperatures at the cutting edge of a tool provided by high cutting speeds may cause a welding action between the chip and the tool, as well as a softening of the tool edge, resulting in poor finish, excessive tool wear, and loss of production. To reduce these high temperatures, refrigeration of the coolant has been successfully employed. Advantages claimed are :—longer tool life, less machine adjustment, closer tolerances, cooler workpieces, control of run-outs, uniform oil viscosity, reduced water consumption, and increased production. Specific examples are quoted.

FOUNDRY.

The Future of the Light Alloy Foundry Industry, by W. C. Devereux. (*Machinery Lloyd*, 7*th July*, 1945, *Vol. XVII*, *No.* 14, *p.* 64, 7 *figs.*)

The output of aluminium castings from 1924 to 1933 remained fairly steady at roughly 10,000 tons a year, but rose at an increasing rate to reach 65,000 tons in 1944. The expansion in the production of magnesium has been even more spectacular in proportion. The bulk of the equipment now available is designed chiefly for small and medium-sized castings and is well suited to the quantity production of equipment, fittings and furnishings for the rehousing programme, for automobile construction, etc. The equipment capable of handling larger castings will be an asset for the ship-building, railway and mechanical engineering fields. The use of mechanisation has been employed to achieve very high outputs despite the severe shortage of skilled foundry workers. The price of primary aluminium has now been reduced, and still further reductions can be made. The effects which this reduction and the improvements in production methods and equipment will produce in the price of engineering light alloy components is considered. The system of quoting for castings in terms of a price per pound is particularly hurtful to light alloys in comparison with the heavy metals. Great advances have been made in the recovery of high quality secondary alloys resulting in another important reduction in costs. If the volume of orders permits the use of the very best patterns and die-equipment and the fullest utilisation of facilities for mechanised production and material handling methods, castings with all the advantages of light metals can be made at very low cost to replace cast and fabricated components of the heavy metals. Among the most striking features of light alloy development in this war have been the way in which alloys have been able to meet the increasing demands placed before them, the pressing into service of alloys which were in the development stage, and the up-grading of medium strength alloys made from secondary materials to fulfil applications for which they were considered unsuitable. In the future the greatest demand will be for alloys which will enable cheap reliable castings to be made in alloys of simple constitution, good casting properties, good resistance to corrosion and ability to take surface finishes. In the field of magnesium casting alloys important developments are anticipated, including greatly increased corrosion resistance. Another property of magnesium alloys which will receive attention of the research metallurgists is the relatively low yield point. The future of the light alloy foundry industry is dependent on research, on new alloys, new castings processes and machines, new ways of making moulds and dies, etc. The author stresses the importance of research by individual firms, co-operative research by associations, and also of research foundations as in the U.S., which would be a great asset to our industrial structure.

MACHINE ELEMENTS.

The Leete System of Three-dimensional Engineering Drawing. (*Machinery, 12th July*, 1945, *Vol.* 67, *No.* 1709, *p.* 37, 12 *figs.*)

Increasing interest has been shown in the possibilities of pictorial drawing for engineering to meet the need for simplifying drawings to the point at which they can be grasped by all. In America production illustration is sponsored by leading aircraft manufacturers, and taught in State-supported schools. The tendency seems to be to set up freehand-drawing courses, where after a 6 to 8-weeks' course, the student is passed into industry trained in the production of perspective drawing. Perspective drawing presents the object exactly as it would be seen by the eye, and requires inherently-gifted freehand artists. The author considers that for small objects it is better to ignore the vanishing points and imagine the object represented with the back as large as the front, *i.e.*, isometrically. After discussing the advantages of pictorial drawings, the need for standardization of methods is put forward. The Leete system of drawing, which employs specially-made templates and charts, and reduces the mechanical drudgery, is advocated. The system is adequately described with the aid of examples. In conclusion, the author discusses the relative merits of trimetric and isometric systems of drawing.

MACHINING, MACHINE TOOLS.

The Copy Principle of Machine Operation, by H. C. Town. (*Machinery*, 19*th July*, 1945, *Vol.* 67, *No.* 1710, *p.* 67, 6 *figs.*)

Principles and applications of mechanical devices are discussed. The pantograph method is based on the principle of similar figures in which corresponding sides or lines are equal or proportional, and also on a second feature that their areas are proportional to the squares of their linear dimensions. In engineering practice the principle is extended to similar solids, and the relation is that volumes of similar solids are proportional to the cubes of their linear dimensions. The best known example of pantograph mechanism is that applied to engraving machines. Linkages are described for :—the Taylor-Hobson milling and die-sinking machine, a method of truing a thread-grinding wheel, the Deckel system with tilting action, and a copy-milling maching with Duplex spindles for roughing and finishing.

Precision Grinding with the Modern Abrasive Wheel. (*Book published by Jones & Shipman, Ltd., Leicester, price* 5/–.)

The book is divided into three sections dealing with operation, wheel selection, and defects, respectively. Each section is adequately covered ; thus, that on operation includes general advice, and sub-sections on in-feed, work and traverse speeds, wheel speeds, balancing and truing, and the production of fine finish. Care has been expended to enable quick reference to be made to any particular item by means of a thumb index and many cross-references.

Fusion Cutting by High-Speed Bandsaw, by R. W. Hancock. (*Sheet Metal Industries, July*, 1945, *Vol.* 22, *No.* 219, *p.* 1205, 6 *figs.*)

Bandsawing and cutting by frictional heat are old and proved processes, but few have realised the advantages to be gained by a combination of both. A standard wookworking bandsaw has been speeded up so that a saw speed of 12,000 ft. per min. and upwards is obtained. Intense heat is generated by friction when work is fed into this saw, and in the case of sheet metal, it is such that the saw is cutting material which will locally be at melting point. The speed of the

saw ensures that the blade itself is kept cool, fast effortless cutting is achieved with no appreciable work-drag or distortion, and a cut can be made in any direction across a contoured pressing without snatching or chattering even when cutting a weak or unsupported section. Armour plate up to 1¼ in. thick, tool steel sections, plate glass, non-ferrous ingots and many forms of plastics have all been cut. In this particular case it was used for trimming unsupported flanges in 20 s.w.g. stainless steel, a full range of press tools not being available. The saw development by means of cutting tests is fully described. As a result of these tests an ordinary woodsaw 7/16 in. wide, ·030 in. thick, with 15 diamond pattern teeth per in., made from ·60 to ·65 per cent, carbon steel with a ·65 to ·75 per cent. manganese content, has been adopted. The high-speed bandsaw has certain definite advantages over the router as work can be guided accurately along a marked line with a width of cut of only 1/16 in., against ¼ in. to ½ in., but the finish is very much rougher. This cutting process is particularly suited to trimming to a marked line or template, but it is possible to use simple cutting jigs. Two jigs are described which present the work at the correct cutting angle as well as guiding it. Jigs may be located on guide rails or against the saw itself. Most woodworking bandsaws will be suitable if they can be safely driven at 1,200–1,300 r.p.m. Indications of the costs are given. Little maintenance is required. For safety it is essential that the operator wears strong leather gloves and efficient goggles.

Centralization Reduces Burring Costs. (*The Machinist*, 14*th July*, 1945, *Vol.* 89, *No.* 14, *p.* 461, 1 *fig.*)

Removal of burrs is a problem that can be handled effectively in mass-production factories by centralizing the operations. Methods can then be applied to eliminate over-allocation of trimming machines and duplication of work.

Machining Gun-mounting Bases on Horizontal Boring Machines. (*Machinery*, 12*th July*, 1945, *Vol.* 67, *No.* 1709, *p.* 29, 10 *figs.*)

Instead of forty-five to fifty different machine set-ups that would normally be required for machining these bases, a practice that necessitates only four has been used. Horizontal boring, drilling, and milling machines are used not only for their usual operations, but also for the turning, boring and facing of large-diameter surfaces. The methods which require the use of heavy rotary and vertical indexing tables are fully described.

Machining Glass-Reinforced Plastic with Cemented Carbide Tools, by Harry Crump. (*The Machinist*, 14*th July*, 1945, *Vol.* 89, *No.* 14, *p.* 467, 3 *figs.*)

The highly abrasive nature of the fine glass dust resulting from machining operations and the high tensile strength of the fibres result in a short life for ordinary cutting tools. Cemented carbide is the most resistant to the destructive effects. Even this material requires special forms, cutting angles and operating procedures to prevent excessive physical contact of cutting edges. The necessary techniques for turning, drilling, boring and milling, tapping, punching and blanking, are described.

Crankshaft Production for the Napier Sabre Engine. (*Machinery*, 19*th July*, 1945, *Vol.* 67, *No.* 1710, *p.* 57, 12 *figs.*)

General review, with especial reference to the more unusual operations.

MATERIALS, MATERIAL TESTING.

The Admiralty Rubber Meter. (*The Engineer*, 29*th June*, 1945, *Vol. CLXXIX*, *No*. 4668, *p*. 504, 3 *figs*.)

An indiarubber article must have suitable physical characteristics, one of the most important being hardness. The Admiralty rubber meter was made to test hardness in accordance with B.S.S.903—1940. The latest pattern, which is described, is a precision instrument from which uniformly accurate and reliable results are obtained.

MEASURING METHODS, INSPECTION.

Checking the Thickness of Cylinders by Electrical Methods, by B. M. Thornton. (*Machinery*, 5*th July*, 1945, *Vol*. 67, *No*. 1708, *p*. 9, 4 *figs*.)

The portable apparatus passes an electric current through the section of the wall to be measured under prescribed conditions and thickness readings are obtained with the aid of calibration curves. Practical precautions are indicated and a particular application is described.

Where Magnetic Particle Testing Stands as an Inspection Tool. (*The Machinist*, 14*th July*, 1945, *Vol*. 89, *No*. 14, *p*. 484, 11 *figs*.)

Magnetic-particle testing is a method for locating invisible surface and sub-surface defects in castings, forgings, machined parts and weldments. Tentative standards for procedure in magnetic-particle testing of steel castings and forgings have been issued by the American Society for Testing Materials. The principle is simple : discontinuities in the metal such as cracks, voids and inclusions give rise to localized leakage fields when the object is magnetized, and these discontinuities can be made evident by attraction of fine magnetic particles to the leakage fields. Sub-surface defects are revealed quicker and cheaper than by radiographic inspection, but the problem of identifying sub-surface defects is considerable. On some kinds of work radiographic inspection may be required as a supplementary test. From experience with steel castings used in critical locations, the Bureau of Ships has drawn conclusions of considerable importance. A fairly full review of present-day methods of both dry and wet types is given, including those using A.C. and D.C. current, and various kinds of fluorescence.

Inspection Efficiency, by J. C. Edwards, and W. A. Bennett. (*The Institution of Mechanical Engineers Journal and Proceedings*, *June*, 1945, *Vol*. 152, *No*. 1, *p*. 69, 7 *figs*.)

The paper outlines the numerous directions in which improvements can be sought in engineering inspection. It shows how direct improvements in efficiency can be effected by carefully planned methods of recording results, including the use of statistical quality control, by adopting the principles of time and motion study in the planning of flow of work through inspection, and in the design of gauging fixtures and the arrangement of gauges. The importance of correct personnel selection and organisation is stressed, as is also the avoidance of duplication of inspection. It concludes by quoting figures showing the substantial reductions which have been achieved in the authors' company by a progressive application of the methods described over a period of several years. Payment by results is used in the inspection department.

PLASTICS.

Moulding Plant for Plastics, by J. Lionel Daniels. (*The Institution of Mechanical Engineers Journal and Proceedings, June,* 1945, *Vol.* 152, *No.* 1, *p.* 44, 7 *figs.*)

Commencing with a general outline of the method of pressure moulding as it may be applied to moulding powders or laminated material, the author passes on to a description of the usual types of hydraulic presses, divided into upstroke, downstroke, angle presses, and sheeting presses. The hydraulic system as applied to moulding presses is then discussed, with a description of hydraulic pumps and accumulators. The relative merits of water and oil as the hydraulic medium are also considered. Modern practice favours self-contained hydraulic pump units where only a few are installed in a factory, and also for very large units which would put an undue strain on the accumulator system. The preheating of material in gas- or steam-heated ovens is described, also preheating by high-frequency high-voltage electric currents. Moulds and platens are heated by steam, gas, or electricity. The injection moulding of materials both of the thermo-plastic and thermo-setting type is discussed, with particular reference to the injection of thermo-plastic materials such as cellulose acetate, and to the injection and transfer moulding of thermo-setting materials such as wood-flour "filled" phenol formaldehyde. Screw-type extruders are used for certain materials such as casein, and form any of the newer thermo-plastic materials, such as "P.V.C." The author then considers the manufacture of tools and dies, and gives a typical layout of the mould and ejector pins. He also describes a 500-ton hobbing press, and the moulds which can be hobbed on this machine. Attention is given to preforming machines for making the plastic moulding powder into "preforms." In the manufacture of laminated sheet, paper or fabric material is impregnated with resin, dried in ovens, and then cut into sheets for pressing. A short description is given of the equipment required.

A Survey of Plastics from the Viewpoint of the Mechanical Engineer, by S. Livingston Smith. (*The Institution of Mechanical Engineers Journal and Proceedings, June,* 1945, *Vol.* 152, *No.* 1, *p.* 29, 54 *figs.*)

The object of the paper is to review the prospects of the use of plastics in mechanical engineering by their application to stressed parts, and attention is therefore concentrated on their mechanical properties. The paper touches on unfilled resins and on moulding powders, but the main emphasis is laid on reinforced plastics and resin-treated woods, and on their possible use as structural members, gears, and bearings. Since the value of any material in engineering practice depends not only on its strength and stiffness, but also on its general serviceability, some consideration is given to other characteristics, which may affect the behaviour of plastics under service conditions. A certain degree of molecular orientation is necessary to obtain high strength and stiffness in synthetic resins and, although strong artificial fibres such as nylon have been produced, the strong element in reinforced plastics is more often the natural cellulose fibre. The synthetic resin is used in an unoriented form to stabilize the cellulose fibres so that they can carry compressive as well as tensile load and to bond the fibres together so that load may be transmitted from one fibre to another. One convenient form of fibre-filled synthetic resin is that of laminated sheet, and some research has been done on paper-filled materials in this form. It is shown that adequate bonding and stabilization of the fibres demands the avoidance of voids in the resin-bonded board, but that otherwise the strongest board is that containing the least resin. Completely to fill the voids in the paper base without the use of excess resin or very heavy pressure requires close control of the processes of impregnation and pressing ; and the minimum amount of resin necessary depends upon the fibre density of the paper. Close attention to

these two aspects has resulted in the development of strong boards with low resin content, which can be completely bonded at low pressures. Most synthetic resins are highly resistant to corrosive agents, but many absorb and desorb water in sympathy with changes of humidity of their surroundings. The amount of water sorbed is not serious, nor is the consequent effect on the strength very great, but the slight swelling and contraction of the materials which results from water sorption may cause trouble in certain applications. The synthetic resins at present available for the bonding of cellulose fibres enable fairly effective use to be made of the strength and stiffness of the fibre ; but there is still room for considerable improvement, which should result in higher strengths in compression and shear and in greater resistance to buckling. Otherwise the further development of plastics depends principally on improvements in manufacturing processes and intelligent application of those processes to the specific problems of engineering design.

RESEARCH.

Radial Rake Angles in Face Milling, by J. B. Armitage and A. O. Schmidt. (*Mechanical Engineering* (*U.S.A.*), *June*, 1945, *Vol.* 67, *No.* 6, *p.* 403, 8 *figs.*)

Part I. The continuation of a previous investigation on cutter characteristics is described. Negative radial rake angles were found to produce stronger cutting tips, the cutting edges of which are generally not as liable to fail from impact as those formed by positive radial rake angles. Power required is higher for the negative radial rake cutter at all speeds up to 1180 fpm. Cutters with negative radial rake stand up longer at the higher speeds. Wear and failure of a positive radial-rake-angle cutter will soon increase its power consumption above that of a cutter with negative radial rake angles. Average temperature of the chips produced does not approach the melting temperature. A cutter with a 15- or 30-deg. positive secondary radial rake angle and provided at the cutting edge with a negative primary radial rake angle 1 to 2 times the width of feed per tooth was found to be a more effective cutter, since it combined the increased strength of the cutting edge afforded by negative radial rake angles and the lower power requirement of the cutter with positive radial rake angles. The effect of various radial rake angles on tool forces are shown graphically.

SHOP ADMINISTRATION.

War Planning for the Post-War Period, by A. Laszlo. (*Mechanical World*, *6th July*, 1945, *Vol.* 118, *No.* 3053, *p.* 7.)

The urgent necessity for standardisation of plant for heavy industries in the U.S.S.R. evolved methods that could be applied to future industrial schemes. The example used is the standardisation, on a vast scale, of steel and tube mills in the Five-Year Plans.

SMALL TOOLS.

Diamond Cutting Tools, by Paul Grodzinski. (*Mechanical Engineering* (*U.S.A.*), *June*, 1945, *Vol.* 67, *No.* 6, *p.* 369, 23 *figs.*)

After a brief mention of early uses of diamond cutting and present-day applications, the fundamentals of diamond as a cutting material are fully considered, and it is pointed out that no actual proof has yet been brought forward as to which is the best or most economical orientation of the diamond crystal when used in the form of a cutting edge. In order to obtain an approximate idea of the efficiency of diamond-cutting without laboratory tests, the author's recommendation is to calculate the cutting path, a good life being 1,500 to 2,000 miles cutting path for

faceted diamond tools. For cutting-tool nomenclature German and Swiss standards are used. When considering cutting conditions for surface-finishing operations, the problem should be considered from the plane of chip flow, *i.e.*, a plane perpendicular to the leading edge. It is necessary to distinguish between tool edges for obtaining optimum surface finish and those for producing special contours, since there has been a tendency to combine these characteristics so as to produce a universal tool edge. The most appropriate tool form for finishing straight cylindrical or plane surfaces is a tool edge with a front adjusting angle of 30 to 45 deg. and a back adjusting angle of 0 to 2 deg. Setting of the diamond by brazing is considered inferior to cold setting, since the latter provides (*a*) elimination of heat, (*b*) ease of removal, and (*c*) possibility of correct relapping. The advantages of diamond tool tips are accompanied by the disadvantage that the actual tool shape cannot easily be changed, and only the adjustment of the tool can be changed in order to obtain optimum results. Mathematical and graphical methods for determining the real clearance and rake angles for adjustable-tool edges are discussed at length. In production, the fixed-type tool should be applied, and the author believes that the field of application of the adjustable tool is in research, in preliminary tests on new materials, and in production problems.

Milling Cutters and How to Use Them, by M. Martellotti. (*The Machinist*, *7th*, 14*th July*, 1945, *Vol.* 89, *Nos.* 13 *and* 14, *pp.* 431 *and* 474, 11 *figs.*)

Part 8. Clearance and relief angles play an important part in cutter performance. The number of teeth and proper chip clearance may be found from the material cut and the nature of the milling operation. The factors affecting clearance angle requirements are first indicated, and values are suggested. A general formula, which gives the clearance angle necessitated by the feed component, width of land, depth of cut, diameter of cutter, and Brinell hardness, is also given, with an alignment chart for its rapid solution. A formula is given for the number of teeth in high-speed milling with sintered carbide cutting material. Worked examples are included.

Part 9. Proper sharpening preserves cutter life. Milling cutters are expensive tools and should be handled with care in order to get efficient cutting action. Clearance angles should be checked after each resharpening, by means of a dial indicator. In grinding, the desired clearance angle is generally obtained by setting the centre of rotation of the grinding wheel a predetermined amount below the centre line of the cutter, while the cutting edge supported by a toothrest is maintained fixed in relation to the grinding wheel. An alignment chart for determining the required offset is given, and its use is explained.

SURFACE, SURFACE TREATMENT.

Surface Roughness Testing, by John M. Trytten. (*Metals and Alloys*, *January*, 1945.)

The importance of waviness is becoming more widely realized. Roughness and waviness irregularities are arbitrarily distinguished at being respectively more closely or more widely spaced than $\frac{1}{32}$ in. Manufacturers are more and more concerned with surface irregularities spaced horizontally from about $\frac{1}{32}$ in. to $\frac{1}{2}$ in. peak to peak. Since these irregularities were beyond the range of the usual surface-roughness measuring instruments, two new instruments were developed for measuring them. For giving an average roughness figure similar to a profilometer reading, a roughness meter has been designed. The fundamental differences are in the use of higher tracing speed and a blunter tracing point. For the accurate measurement of waviness up to $\frac{1}{2}$ in. or more (peak-to-peak spacing), a

displacement recorder known as the Recordagage has been offered to industry. This recorder makes a profile of the actual configuration of surface irregularities, including the larger roughness, waviness, eccentricity, and other displacements of all sorts. It is a recording-type instrument, with the reading or profile appearing on a continuous chart. Magnification vertically is 2500X ; horizontally, magnification is controlled by the tracing speed in relation to chart speed.

(*Communicated by U.S. Office of War Information, London.*)

Building-up and Hard Surfacing by Welding, by William Andrews. (*The Institution of Mechanical Engineers Journal and Proceedings, June*, 1945, *Vol.* 152, *No.* 1, *p.* 1.)

The paper describes the use of fusion welding for renewing worn or corroded parts and points out that it can equally well form part of the original design for many structures. The characteristics of the various welding processes are considered, expecially the metallic arc, since it has by far the largest scope. Some illustrations of the type of weld deposit practicable are considered, and the more limited developments in the metal of non-ferrous metals and "super-hard" alloys are referred to. A very wide variety of commercial products is available for the process, particularly in the direction of electrodes for metallic arc welding, but information as to alloy compositions used, and their response to fusion with different parent metals, is lacking.

Problems Connected with Reclamation of Worn Parts by the Metal-spraying Process, by W. E. Ballard. (*The Institution of Mechanical Engineers Journal and Proceedings, June*, 1945, *Vol.* 152, *No.* 1, *p.* 4.)

In peace the salvaging of worn parts is not usually a major problem, and the returning of old parts to service has not in the past received enough attention. Although metal spraying by the wire process has become more widely known during the past two decades, the number of engineers who would feel competent to judge its suitability for any repair is comparatively small. The object of the paper is to describe certain matters of interest to engineers in connection with salvage. To assist engineers faced with the problem of repairing a worn part, the author has arranged the paper in the form of answers to the following questions : (*a*) Is metal spraying a suitable method of reclamation ? (*b*) If so, how must the work be prepared for spraying ? (*c*) What method of spraying and which metal should be used ? (*d*) What finish is necessary ?

The Repair of Worn or Over-machined Parts by Electrodeposition, by A. W. Hothersall. (*The Institution of Mechanical Engineers Journal and Proceedings, June*, 1945, *Vol.* 152, *No.* 1, *p.* 8, 9 *figs.*)

Worn or over-machined parts may be resorted to size by electrodeposition of nickel or chromium followed by machining or grinding to remove excess of deposit. The mechanical properties and the adhesion of these deposits are described with special reference to nickel. It is shown that strongly adherent nickel coatings can contribute appreciably to the tensile strength of the steel upon which they are deposited. Electrodeposited coatings may reduce the fatigue strength of steel and their use on parts subject to high alternating stresses should be made with caution. General notes on the process are given for the guidance of users. An informative discussion on the above paper is also given.

Applications of the Jet Pickling Process, by W. E. Grant. (*The Machinist*, 30*th June*, 1945, *Vol.* 89, *No.* 12, *p.* 391, 1 *fig.*)

War needs led to improvements in the jet pickling process. In jet pickling chemical reaction is accelerated by the force of the sprays. Soluble oxides are more rapidly removed than in the immersion method, and insoluble oxides are brushed off by the jets after soluble oxides underneath are dissolved. The cost, design, operation and output of jet plants are discussed for the continuous pickling of strip, steel pressings and fabricated articles. Designs have already been evolved, and some plants built, for hollow-ware, cartridge cases, bomb parts, food containers, strip, wire in coils, wire in strands, forgings and castings, pressings, rods, tubes, and sheet metals.

Works Practice in the Pickling of Steel, by E. Marks. (*Sheet Metal Industries July*, 1945, *Vol.* 22, *No.* 219, *p.* 1179, 8 *figs.*)

This article concludes a series on pickling, and is intended to link up the work of two previous writers who considered the subject from different standpoints.

Corrosion of Ferrous Metals, Its Causes, Prevention and Removal. (*Power Transmission*, 15*th July*, 1945, *Vol.* 14, *No.* 162, *p.* 595.)

This report describes briefly how to prevent corrosion formation on iron and steel, and how to remove it when it does occur.

WELDING.

The Technical Control of Resistance Welding, by H. E. Lardge. (*Sheet Metal Industries, July*, 1945, *Vol.* 22, *No.* 219, *p.* 1241, 9 *figs.*)

The best check of any weld is a test to destruction, but for welds which have to go into service the only method is to make certain that the operating conditions, under which good welds are known to have been made, are maintained. The author shows how control of welding can be achieved through a welding technical department, working in close collaboration with the other departments concerned. This department should control all welding plant, carry out experimental work, issue specifications to the shops, investigate any deterioration in welding, and collaborate with designers at an early stage. Its relations with the following are discussed : Metallurgical laboratory, designs department, production department, welding personnel, inspection, maintenance department, and time study.

WOODWORKING.

Use of Modern Coated Abrasives in Woodworking Industries, by Thomas Trowbridge. (*Mechanical Engineering* (*U.S.A.*), *June*, 1945, *Vol.* 67, *No.* 6, *p.* 387, 10 *figs.*)

Important developments and improvements made during recent years in the manufacture of coated abrasives, have greatly increased their efficiency as cutting tools. The greatest quantity is consumed in the manufacture of furniture and allied products, and this article is confined chiefly to the use of coated abrasives for these purposes. The developments include : a new principle of coating ; improvements in roll backings ; development of various degrees of cloth flexibility ; heat-treatment of garnet grain ; improvements in aluminum-oxide minerals and the invention of electrostatic coating. The selection of abrasive paper, type of sander to use, including flat-belt sanding, molding sanding, and mechanical finishing, are discussed.

INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A *and* B. *Advertisers' announcements only appear in one edition each month, advertisements in edition* A *alternating with those in edition* B *the following month. This Index gives the page number and edition in which the advertisements appear for the current month.*

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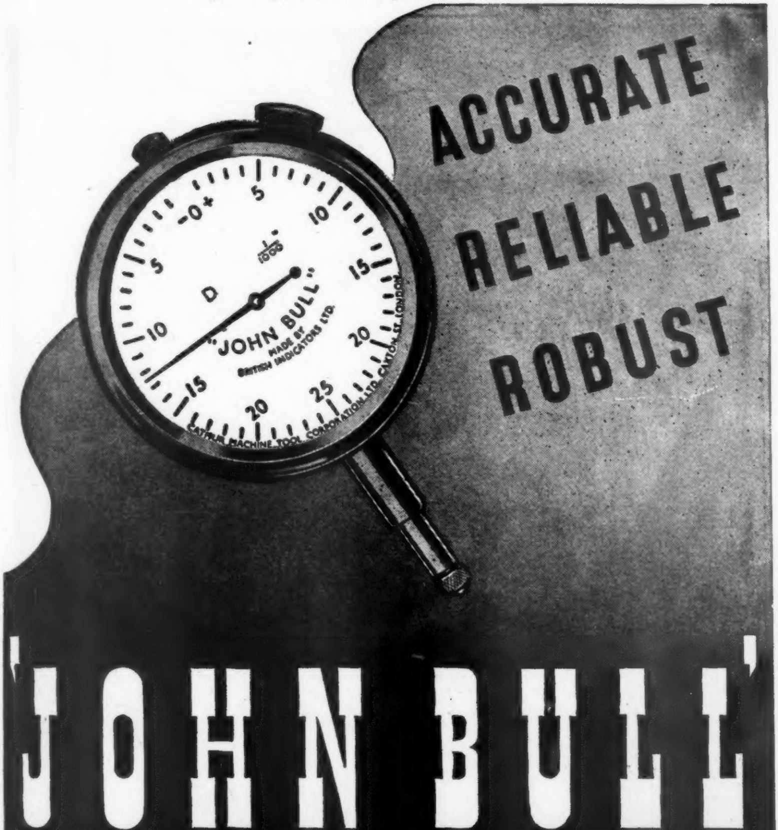

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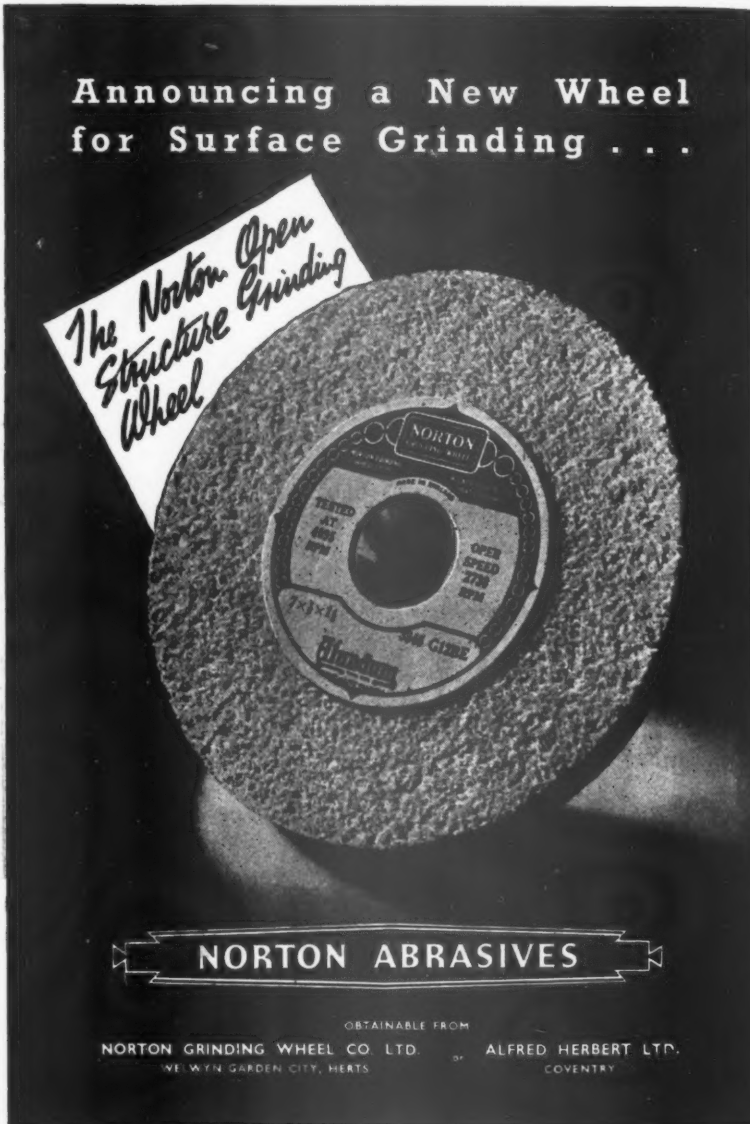
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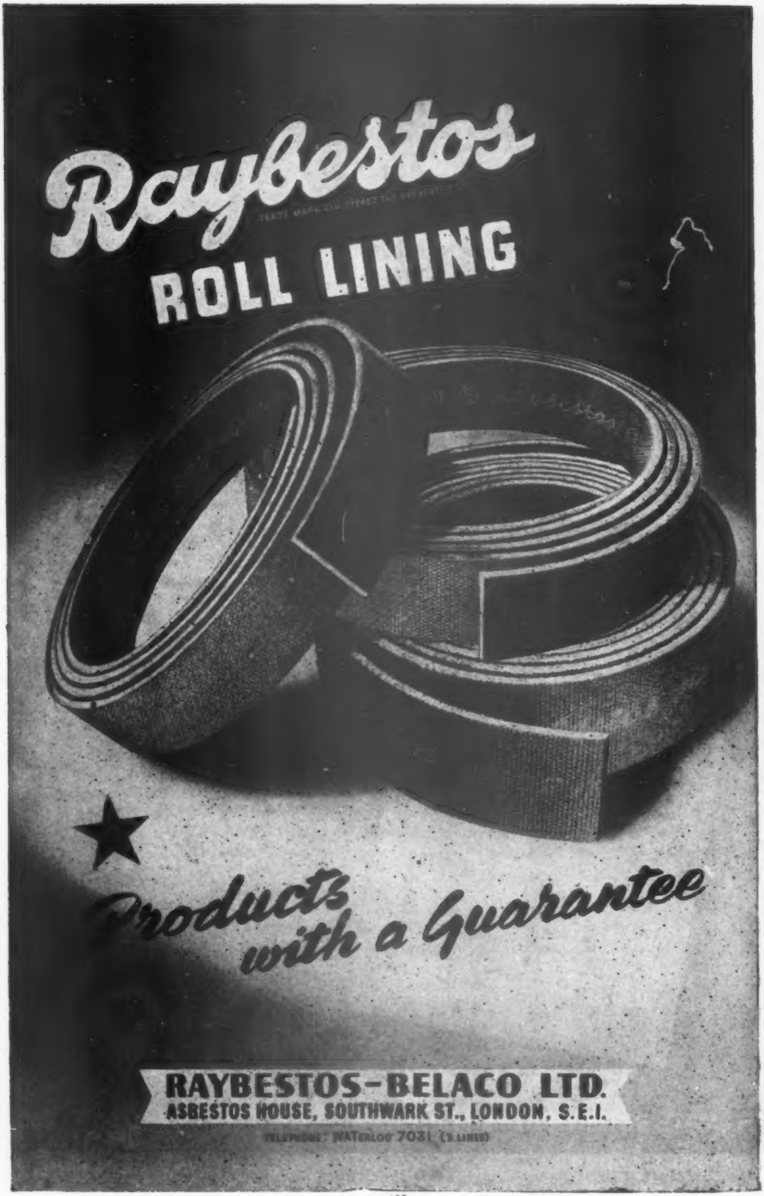
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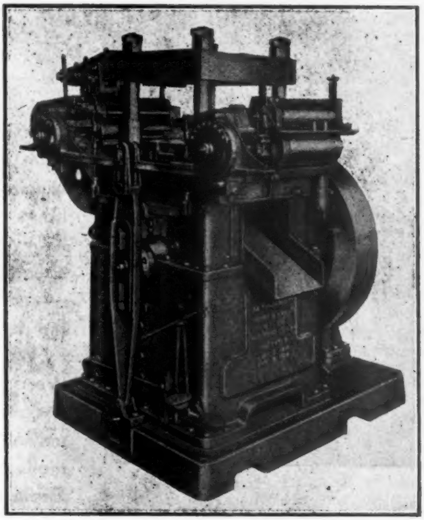

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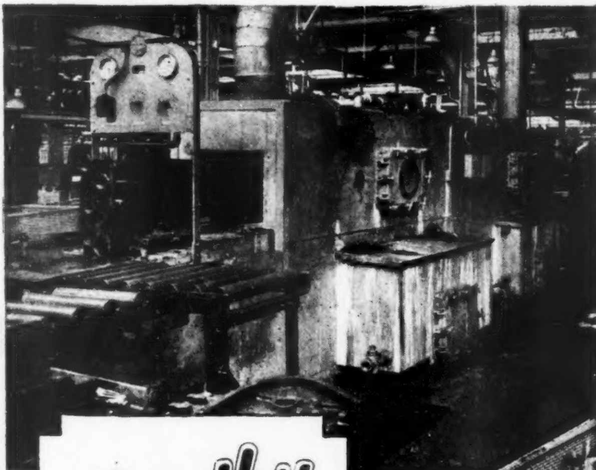

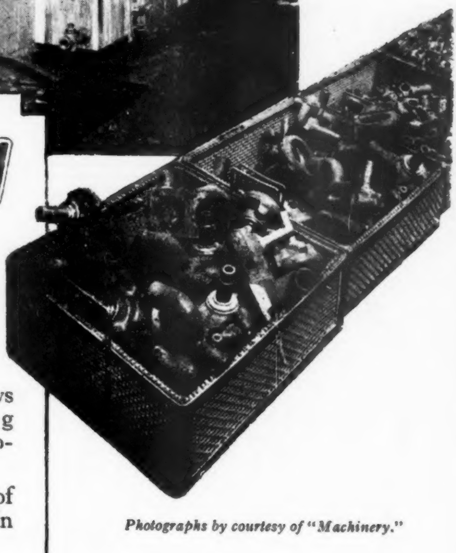

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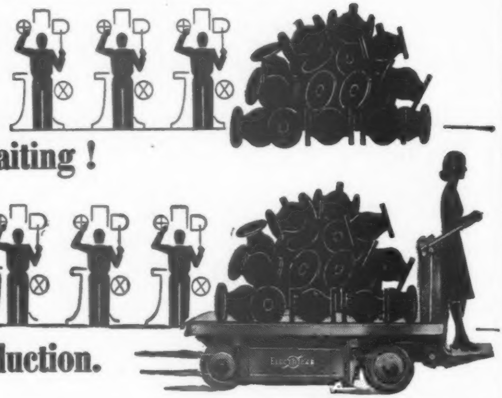

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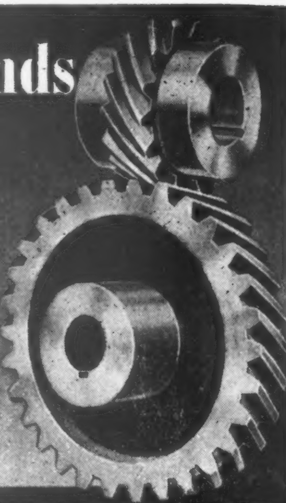

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MG 3

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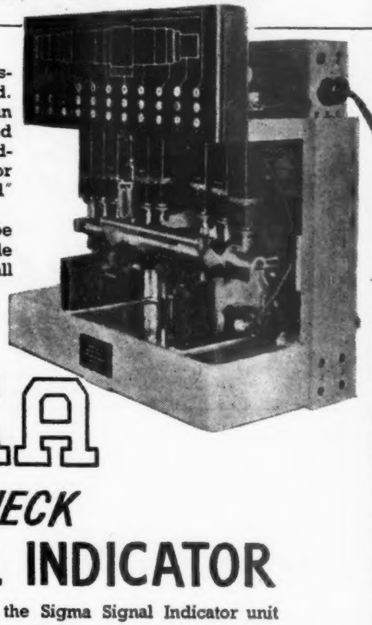

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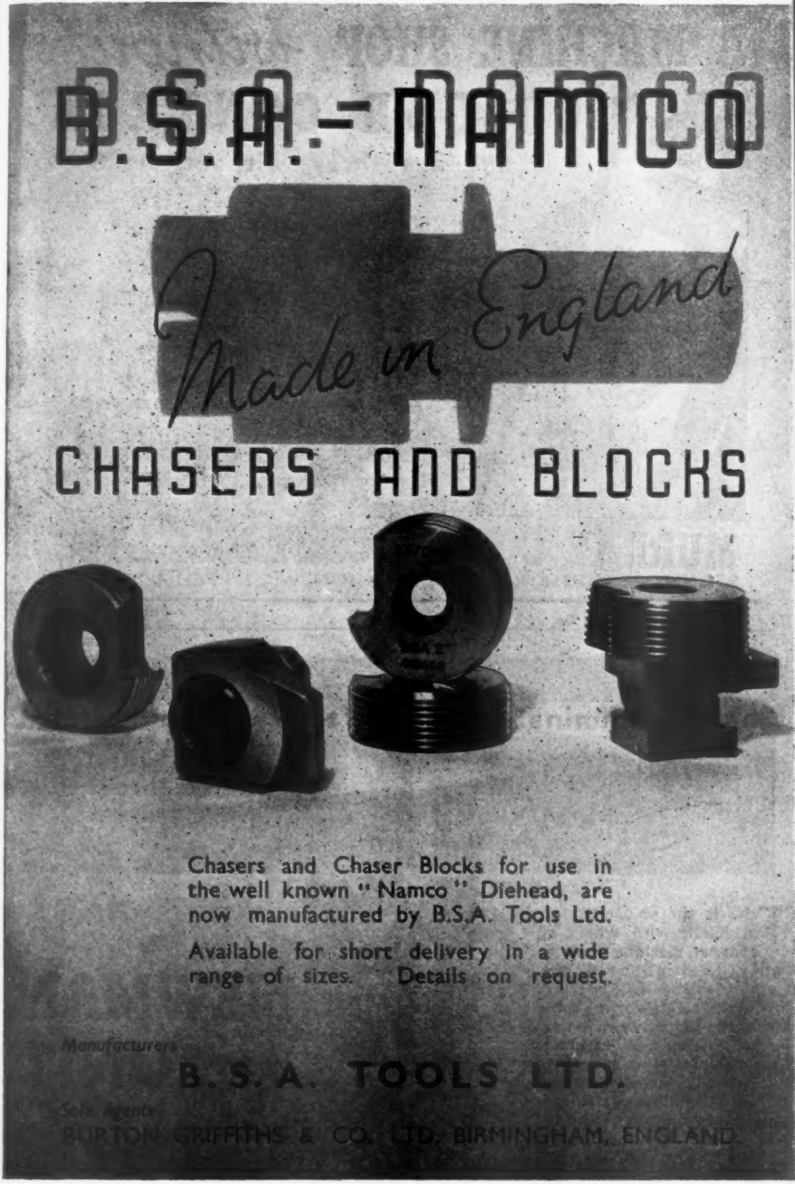
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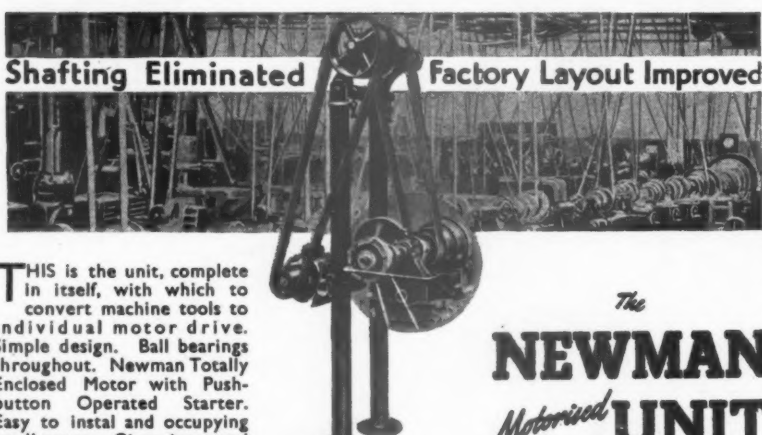

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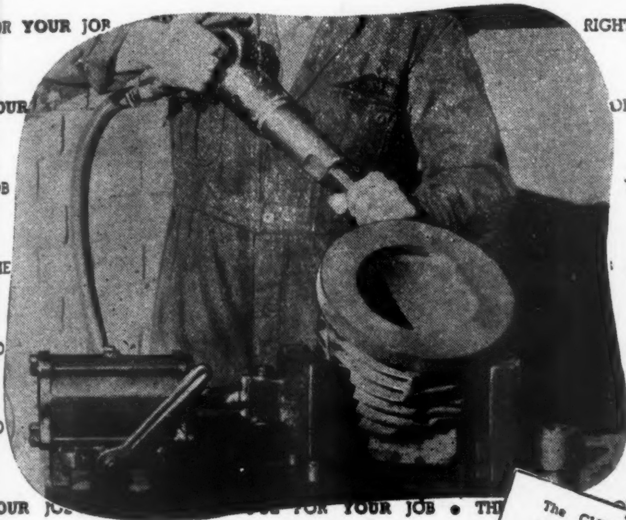

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